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ABSTRACT

This part of a 2-part working paper identifies and describes major occupational groups that are characteristic of high technology manufacturing and service industries as well as employment sectors that use high technology products in their provision of goods and services. The paper is based on a review of a wide range of employment projections made by federal agencies, independent forecasters and others, and was prepared in the hope that these indicators may provide a foundation upon which an equitable distribution of new high technology jobs to women can be built. An introduction discusses women's employment in the high technology industries today and in the future. The occupational profiles are divided into four sections. Section I groups technical occupations that are typical of microelectronics-based manufacturing and other industries that have adopted computerized systems. These range from bench assemblers to electrical engineers. Section II discusses computer-based jobs that are becoming common in most employment sectors. The primary focus is on data processing professionals and computer operators. Section III profiles selected occupations, complementary to high technology but also associated with other employment sectors. These include mathematics specialists and sales and marketing personnel. These first three sections provide job descriptions and requirements and employment and earnings data. Section IV covers technical occupations that are developing in response to emerging technologies. The focus is on defining the technologies rather than on specific occupations. Appendixes include three charts showing the job outlook in brief for over 200 jobs grouped into 18 occupational clusters and the importance of mathematics and science respectively to future employment opportunities. (YLB)

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BRIDGING THE SKILLS GAP
WORKING PAPER
PART II: HIGH TECHNOLOGY AND RELATED OCCUPATIONS

by
Christine E. Kaplan
May, 1984

A Project of the Women's Work Force Division
of
Wider Opportunities for Women, Inc.

CE043431

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HIGH TECHNOLOGY AND RELATED OCCUPATIONS

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WORK FORCE OF TOMORROW - AN INTRODUCTION

As part of the **Bridging the Skills Gap Project,** Wider Opportunities for Women has assessed the implications of technological change for women in the labor force. Although various labor economists have stressed that high technology industries as a group will not completely solve the nation's unemployment problems, WOW has viewed the dynamic transition to an advanced technology-based economy as an opportunity to assess new employment options for women and a time to reexamine the occupational structure of the female work force.

WOW's initial interest in high technology industries grew from the organization's direct involvement in nontraditional training of women in electronics and electromechanics and the experiences of the 140 affiliate members of WOW's Women's Work Force Network, which are independent, community-based employment programs engaged in providing and/or promoting skills training and related services for women. In addition, WOW's role as a national advocate of equal employment opportunity and economic self-sufficiency for women reinforced the need to go beyond the development of specific training options and analyze the social, economic and political issues precipitated by the emergence of high technology industries and the widespread applications of advanced technologies in today's economy.

A Few Facts About Women's Employment

- Since 1970 the participation rate for women in the work force has steadily increased from 43% to 53% in 1982. By 1995 more than 60% of all women will be in the paid labor force. (The participation rate for men is projected to decline to 76% by 1995.)

- The number of women as a proportion of all workers grew from 38% in 1970 to 43% in 1982. By 1995 women workers will constitute approximately one-half of the total labor force.

- Most women work out of economic necessity. For example, women represented the largest category of those in poverty in 1982 and headed 50% of all families below the poverty threshold. About 75% of all families headed by women of color were living in poverty that year.

- Women continue to be segregated in low-wage and low-status occupations with the majority employed as clerical and service workers even though their educational attainment is equivalent to men. On the average women are paid about 60 cents for every $1 their male counterparts receive in earnings.

These and other related factors underscore the need to open up new job markets to women in high tech, other developing areas and established "nontraditional" fields. We have entered an era where many workers will require retraining and those planning careers will have to prepare themselves for new kinds of occupations. This provides an opportunity to rectify past practies and injustices by formulating educational, training, and employment policies that treat women on a more equitable basis.

Employment During the 1980's and Beyond

As part of the research for the **Bridging the Skills Gap Project** WOW has reviewed countless employment projections made by federal agencies, independent forcecasters and others. Forecasts made by the Bureau of Labor Statistics (BLS) demonstrate that the greatest growth (number of new jobs) will occur in nontechnical occupations. Among the list of ten fields with the largest growth between 1982 and 1995 are eight traditional women's occupations including cashiers, secretaries, general office clerks, salesclerks, registered nurses, waitresses, primary school teachers and nursing aides.

When the list is expanded to the forty **occupations with the greatest growth**, however, several technical occupations which are characteristic of employment in high technology and user industries are covered. These include technical sales representatives, electrical and electronic technicians, computer systems analysts, electrical engineers, computer programmers and computer operators.

Furthermore, among the twenty **fastest growing occupations**, four of the top five are computer-related and nine are typical of high tech work places. These jobs include computer service technicians, computer systems analysts, computer programmers, computer operators, electrical engineers, peripheral EDP equipment operators, electrical and electronic technicians, mechanical engineers and mechanical engineering technicians. **Tables A** and **B** on the following page show the BLS projections.

Unfortunately the federal government does not report separately the many new occupational specialities emerging from high technology (although these may in part be covered by more generic job titles, e.g. electronic technician). Marvin Cetron of Occupational Forecasting Inc. and other "futurists" have predicted significant growth for several new jobs that are based on the application of advanced technologies. Cetron forecasts that 1990 employment will exceed 250,000 for each of the following occupations industrial robot production technicians, industrial laser

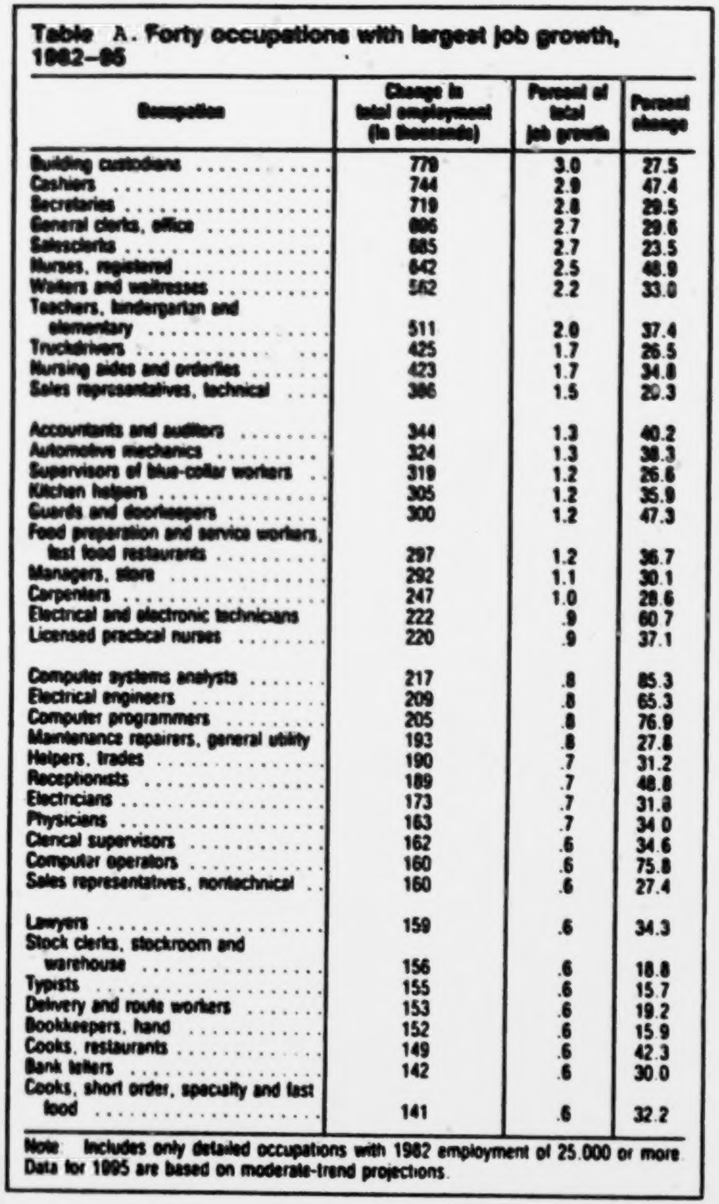


Table A. Forty occupations with largest job growth, 1982–95

Occupation	Change in total employment (in thousands)	Percent of total job growth	Percent change
Building custodians	779	3.0	27.5
Cashiers	744	2.9	47.4
Secretaries	719	2.8	29.5
General clerks, office	696	2.7	29.6
Salesclerks	685	2.7	23.5
Nurses, registered	642	2.5	48.9
Waiters and waitresses	562	2.2	33.0
Teachers, kindergarten and elementary	511	2.0	37.4
Truckdrivers	425	1.7	26.5
Nursing aides and orderlies	423	1.7	34.8
Sales representatives, technical	386	1.5	29.3
Accountants and auditors	344	1.3	40.2
Automotive mechanics	324	1.3	38.3
Supervisors of blue-collar workers	319	1.2	26.6
Kitchen helpers	305	1.2	35.9
Guards and doorkeepers	300	1.2	47.3
Food preparation and service workers, fast food restaurants	297	1.2	36.7
Managers, store	292	1.1	30.1
Carpenters	247	1.0	28.6
Electrical and electronic technicians	222	.9	60.7
Licensed practical nurses	220	.9	37.1
Computer systems analysts	217	.8	85.3
Electrical engineers	209	.8	65.3
Computer programmers	205	.8	76.9
Maintenance repairers, general utility	193	.8	27.8
Helpers, trades	190	.7	31.2
Receptionists	189	.7	48.8
Electricians	173	.7	31.8
Physicians	163	.7	34.0
Clerical supervisors	162	.6	34.6
Computer operators	160	.6	75.8
Sales representatives, nontechnical	160	.6	27.4
Lawyers	159	.6	34.3
Stock clerks, stockroom and warehouse	156	.6	18.8
Typists	155	.6	15.7
Delivery and route workers	153	.6	19.2
Bookkeepers, hand	152	.6	15.9
Cooks, restaurants	149	.6	42.3
Bank tellers	142	.6	30.0
Cooks, short order, specialty and fast food	141	.6	32.2

Note: Includes only detailed occupations with 1982 employment of 25,000 or more. Data for 1995 are based on moderate-trend projections.

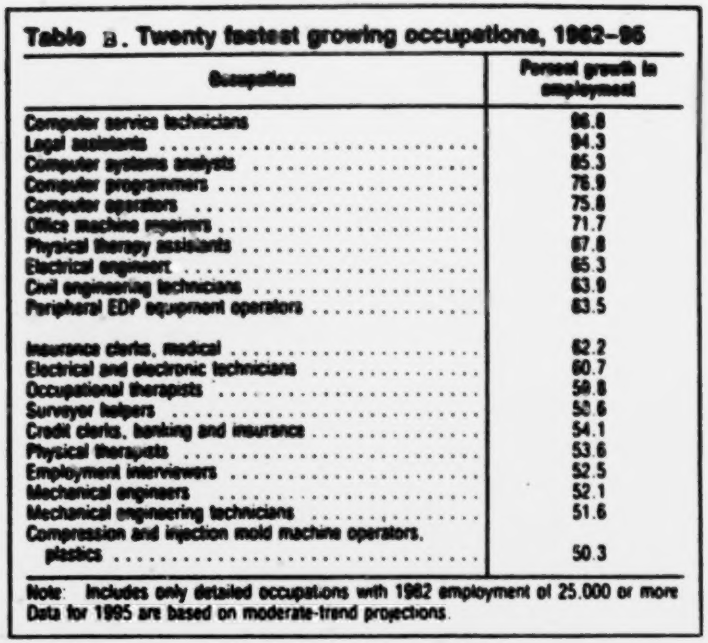


Table B. Twenty fastest growing occupations, 1982–95

Occupation	Percent growth in employment
Computer service technicians	96.8
Legal assistants	94.3
Computer systems analysts	85.3
Computer programmers	76.9
Computer operators	75.8
Office machine repairers	71.7
Physical therapy assistants	67.8
Electrical engineers	65.3
Civil engineering technicians	63.9
Peripheral EDP equipment operators	63.5
Insurance clerks, medical	62.2
Electrical and electronic technicians	60.7
Occupational therapists	59.8
Surveyor helpers	58.6
Credit clerks, banking and insurance	54.1
Physical therapists	53.6
Employment interviewers	52.5
Mechanical engineers	52.1
Mechanical engineering technicians	51.6
Compression and injection mold machine operators, plastics	50.3

Note: Includes only detailed occupations with 1982 employment of 25,000 or more. Data for 1995 are based on moderate-trend projections.

Source: Silvestri, George T., John M. Lukasiwicz, and Marcus E. Einstein, "OccuPational Employment Projections through]995", Monthly Labor Review (November]983), 37-49.

process technicians, computer-aided design (CAD) technicians, computer-aided manufacturing (CAM) specialists, computer-aided vocational training (CVT) technicians, and genetic engineering technicians among others. **Table C** provides a list of selected job opportunities for the next ten years.

While many participants in the high tech employment dialogue may argue over the accuracy of employment projections, WOW believes they serve well as reasonable indicators of occupational trends. These indicators can provide a foundation from which to commence building an employment policy framework that will encourage -- and hopefully ensure -- an equitable distribution of new jobs in these fields to women. Since many women (as do many men) lack the requisite skills for these and other kinds of technical jobs, one key element for the framework has to be the preparation of women through educational and training programs that will allow them to beidge the skills gap.

Many analyses of employment projections forecast that the shift to an information-based economy will promote an equalizing effect on the demographic makeup of future occupational groups and new industries. These scenarios are often based on the notion that a reduction in the manual labor content of work (one of the traditional rationales used to "explain" occupational segregation of the sexes) combined with the emergence of nonsex-stereotyped jobs will eliminate previous inequities in the paid labor force.

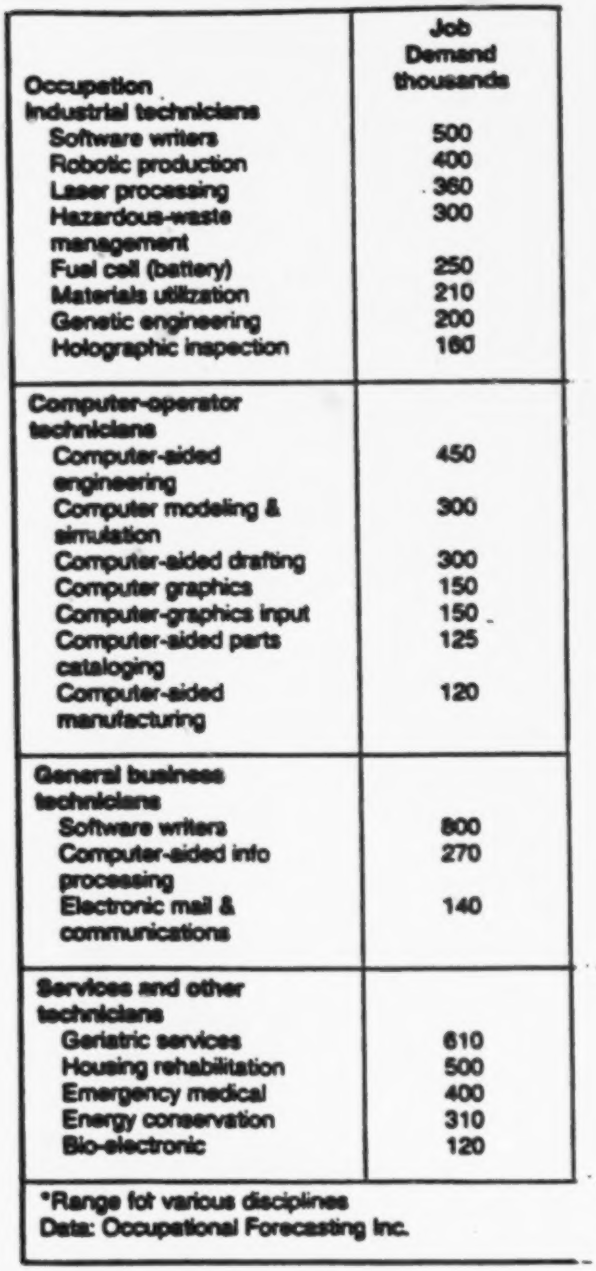
Furthermore it is assumed that because a substantial proportion of the existing work force may have to be retrained, women and men will have equal access to programs that will prepare them for skill changes on the job and/or for new careers. While it may be logical to draw these conslusions, it appears that several policy changes will have to be implemented to alter the systemic patterns of the past that have fostered and continue to maintain occupational segregation and wage inequities for women.

In general new approaches are needed to promote and provide access to eductional programs for women and girls in math, science and other technical subjects as well as include women in retraining programs that prepare them for technical jobs that are sex-stereotyped for men (e.g. engineering) and new fields. These changes will require the "reeducation" of many policymakers, educators, employers and other to accept women as technical employees, to realize the significance of women to the work force, and to recognize the very real economic needs of all working women.

Women in the Technical Workforce

In **Part I** of the Working Paper WOW verified several indicators of continued occupational segregation in the high technology sector based upon its review of selected manufacturing and service industries. The findings substantiate the face that the majority

TABLE C. JOB OPPORTUNITIES FOR THE NEXT TEN YEARS



Occupation	Job Demand thousands
Industrial technicians	
Software writers	500
Robotic production	400
Laser processing	360
Hazardous-waste management	300
Fuel cell (battery)	250
Materials utilization	210
Genetic engineering	200
Holographic inspection	160
Computer-operator technicians	
Computer-aided engineering	450
Computer modeling & simulation	300
Computer-aided drafting	300
Computer graphics	150
Computer-graphics input	150
Computer-aided parts cataloging	125
Computer-aided manufacturing	120
General business technicians	
Software writers	800
Computer-aided info processing	270
Electronic mail & communications	140
Services and other technicians	
Geriatric services	610
Housing rehabilitation	500
Emergency medical	400
Energy conservation	310
Bio-electronic	120

*Range fot various disciplines
Data: Occupational Forecasting Inc.

Source: Port, Otis, "Business in the Year 2001", Business Week's Guide to Careers (Fall/Winter 1983), 53-55.

of women employed by microelectronic-related businesses hold the lowest-paid, lowest-status jobs even though their participation rates are relatively high.

In a sample of four high tech manufacturing industries WOW found that although each was characterized by a high proportion of technical workers, the participation of women in white collar technical and professional positions was far below the average for all workers in these industries. Sixty percent of all workers in the group held white collar jobs in 1982 and three-quarters of these were mangerial, professional or technical positions. In contrast, while nearly 46% of women employed held white collar jobs, only two-fifths held upper level positions with the majority in the traditional group for women -- office and clerical jobs. Although 40% of all workers held blue collar jobs, nearly 54% of women were employed in this group and predominated in the lowest wage (operative) category.

Why do so few women work in technical jobs? Participation rates for women in technical occupations at all levels are disappointingly low. Although positive changes are slowing occurring, the corresponding rates are not fast enough to keep pace with present and near-term demands for technical personnel. While the number of women in the field of engineering has grown -- 11% of all engineering graduates in the 1981-82 academic year were women -- this population (less than 10,000 women) is exceedingly small. According to statistics covering that year by the Engineering Manpower Commission and College Placement Council:

- 8% of all bachelor's degrees in electrical engineering were awarded to women (1,280) and only eleven (out of 538 candidates) women earned Ph.Ds.
- 18% of all bachelor's degrees in computer engineering were earned by women (476) and only 9 (out of 120 candidates) women received Ph.Ds.
- 36% of all bachelor's degrees in computer sciences went to women (8,577) and 22 (out of 239 candidates) women were awarded Ph.Ds.

Labor force participation rates further reflect the underrepresentation of women in technical occupations. During 1982 women accounted for 5% of all engineering jobs, 28% of computer specialists jobs and 17% of engineering and science technicians. **Table D** provides additional detail.

There are a variety of factors that influence the low representation of women in technical occupations. In general these relate to the "nontraditional" nature of many of these jobs that in the past have been considered for males only. Many girls and women

TABLE B.

RATIO OF FEMALE TO MALE EARNINGS FOR SELECTED TECHNICAL OCCUPATIONS*

1982

Occupation	% Women Employed in Field	% Women's Earnings of Men's	Number of Women (000s)
Computer specialists	28	76	199
Computer programmers	32	80	123
Systems analysts	26	75	65
Engineers	5	81	80
Aeronautical/Astronautical	3	92	2
Electrical/Electronic	4	74	16
Math specialists	35	62	13
Mathematicians	13	90	1
Statisticians	50	63	9
Operations and systems researchers and analysts	31	76	73
Teachers (college and university)	26	79	110
Physics	8	66	1
Mathematics	19	89	7
Engineering and science technicians	17	78	178
Drafters	17	80	46
Electrical/electronic	12	76	36
Industrial engineering	33	77	4
Other technicians (except health, engineering and science)	23	61	40
Tool programmers, numerical control	14	85	1

*Based on weekly earnings for all industries.

Source: U.S. Department of Labor, Bureau of Labor Statistics, Unpublished Tabulations from Current Population Survey, 1982 Annual Averages (1983).

have encountered educational, employment and societal barriers that have not supported or encouraged their participation in programs that will prepare them for a high tech world. For example, public educators continue to consider mathematics, science and related coursework "for boys only". It is still common for a teacher or counselor to tell a girl that she "won't need math after marriage." As a result it is not surprising that girls tend to perceive math as less useful as several studies have shown. At a time when the public and policy makers are addressing quality of education issues it is imperative that curriculum design, text book selection and teacher training and retraining consider the needs of all students as they prepare for future employment, education or training.

In addition, for the many students who do not go on to college, vocational training in high school or at the post-secondary level can be one of the few alternatives for effective career preparation. Although approximately one-half of all vocational education students are women, the overwhelming number are steered into programs for traditional "female" jobs. If women continue to be descouraged from entering technical fields they will lose out on valuable upcoming programs that are being specifically designed to prepare workers for the increasing number of technician jobs arising in high tech and user industries.

Why should more women seek technical employment? There are obviously many reasons that influence occupational decisions. Many women may not wish to pursue technical jobs but those who do should be treated equitably as they prepare, seek and gain employment. One reason WOW advocates "nontraditional" employment for women is improved earnings. It appears that women who hold skilled positions in technical fields are narrowing the wage gap. Earnings data reported by the Bureau of Labor Statistics demonstrate that on the average women working in technical occupations earn more than two-thirds of men's wages for the same kinds of jobs.

During 1982, women who worked as electrical and electronic engineers earned 74% of their male counterparts earnings. Similarly women employed as computer programmers, systems analysts, mathematicians, operations analysts, engineering and science technicians and numerical control tool programmers averaged at least 75% of the wages men were paid for performing those jobs. These and related statistics are presented in **Table D.** WOW finds these data encouraging for the relatively few women who have entered nontraditional technical and professional fields and they have reinforced WOW's commitment to promoting policies that will encourage the entry of more women into these and related occupations.

Nevertheless, it must be noted that a wage gap persists even in these fields. Furthermore a recent study conducted at Stanford University implies that earnings differences continue to occur when women enter "nontraditional" professions because they are channeled into less lucrative speciaties. For example, in medicine, women are more likely to work for a clinic than in private practice. The researchers concluded that "women get a ticket to ride after the train has left the station."

OCCUPATIONAL PROFILES - AN OVERVIEW

The following sections of the **Working Paper** identify and describe major occupational groups which are characteristic of high technology manufacturing and service industries as well as employment sectors that use high tech products in their provision of goods and services. The selection of occupations was based on positive employment opportunities for the future, the relationship of these jobs to the industries examined in **Part I** of the **Working Paper** and the representation of occupations at varying skill levels. There are obvious omissions -- as explained in Part I the project methodology excluded industries in the fields of biotechnology and other medical/health-oriented technologies. Consequently the many emerging occupations associated with those fields are not covered.

The occupational profiles are divided into four sections. **Section I** groups technical occupations that are typical of microelectronics-based manufacturing and other industries that have adopted computerized systems. These range from bench assemblers to electrical engineers. **Section II** discusses computer-based jobs that are quickly becoming common in most employment sectors. The primary focus in this section is on data processing professionals and computer operators.

Section III profiles selected occupations that are complimentary to high tech but are also associated with other employment sectors. These include mathematics specialists, sales and marketing personnel, and others. **Section IV** covers technical occupations that are developing in response to emerging technologies. The focus of this section is directed toward defining the technologies rather than specific occupations (although several are identified) since little information is available regarding these jobs of the future.

The formats of the first three sections are comparable with most profiles including job descriptions and requirements as well as employment and earnings data. The primary source used for the descriptive occupational information was the 1982-83 edition of the Occupational Outlook Handbook (April 1982) prepared by the U.S. Department of Labor's Bureau of Labor Statistics (BLS). The primary sources used for employment projections were the 1982 Edition of Occupational Projections and Training Data (December 1982) and the November 1983 Edition of the Monthly Labor Review (both are BLS publications).

Definitions of the technologies described in Section IV are based primarily on those provided by the Office of Technology Assessment in Computerized Manufacturing Automation: Employment, Education and the Workplace (April 1984). Employment projections for this section are based on the work of Marvin Cetron as presented in "Jobs with a Future", The World of Work: Careers and the Future published by the World Future Society in 1983 as well as other published sources.

Following the four sections are three appendices. **Appendix A**, "The Job Outlook in Brief", is reprinted from the Spring 1984 Edition of the Occupational Outlook Quarterly, and covers occupations associated with various employment sectors of the U.S. economy and employment prospects for the 200+ jobs included in the list. **Appendix B** demonstrates the importance of mathematics in 100 occupations and **Appendix C** correlates branches of science with selected occupations in the physical sciences. The latter two appendices are provided to emphasize the importance of math and science to future employment opportunities.

SECTION I. HIGH TECHNOLOGY INDUSTRY OCCUPATIONS

This section covers occupations primarily associated with manufacturing activities in high technology industries. For those unfamiliar with the organizational structure of an industrial facility see **Figures I-A** and **I-B** which diagram the organization of a typical manufacturing firm and steps in the manufacturing process.

Occupation: **ENGINEER (all fields)**

Employment, 1982 (000s)	1,204	
Women, % of total	5%	
Men, % of total	95%	
Median weekly earnings, 1982	$586	
Women (% of men's wages)	479	(81%)
Men	592	
Employment, 1995 (000s)	1,788	
% change, 1982-95	49%	

Source: U.S. Department of Labor,
Bureau of Labor Statistics

Job Characteristics

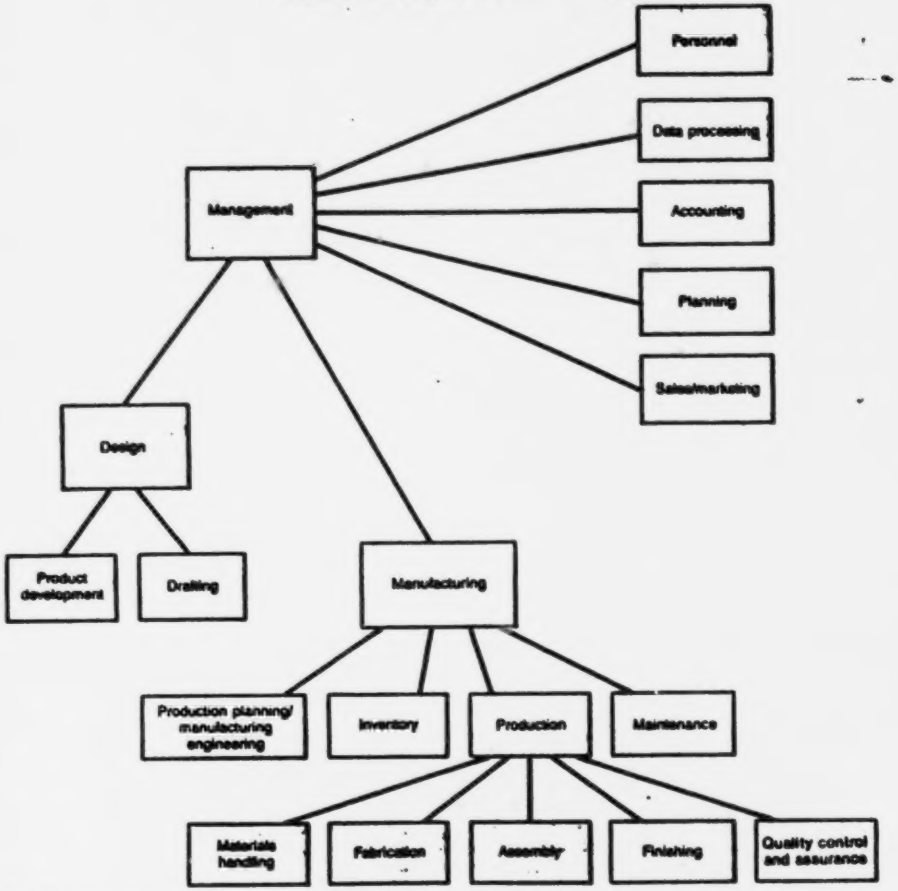
Engineers apply the theories and principles of science and mathematics to practical technical problems. Often their work is the link between a scientific discovery and its useful application. Engineers design machinery, products, systems and processes for efficient and economical performance.

Engineers in high technology industries are often challenged by technical problems associated with the design of electronic products or devices. They must determine the way the device will work, design and test the components, and incorporate them into an integrated system. Engineers are also responsible for evaluating the overall effectiveness of the new product as well as its cost and reliability.

Some high tech engineers may design scientific equipment to probe outerspace as well as weapons and defense systems for the federal government while others may specialize in the design and development of products associated with the automation of manufacturing, business and management processes.

Figure I-A.

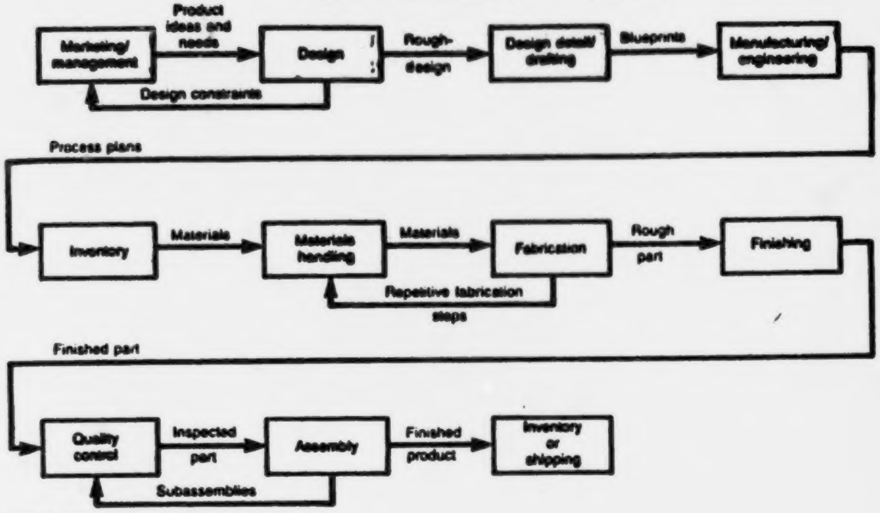
Organizational Diagram of a Manufacturing Firm


Management
Personnel
Data processing
Accounting
Planning
Sales/marketing
Design
Product development
Drafting
Manufacturing
Production planning/ manufacturing engineering
Inventory
Production
Maintenance
Materials handling
Fabrication
Assembly
Finishing
Quality control and assurance

SOURCE Office of Technology Assessment

Figure I-B.

Steps in the Manufacturing Process (Simplified)


Marketing/ management
Product ideas and needs
Design
Design constraints
Rough-design
Design detail/ drafting
Blueprints
Manufacturing/ engineering
Process plans
Inventory
Materials
Materials handling
Materials
Fabrication
Repetitive fabrication steps
Rough part
Finishing
Finished part
Quality control
Inspected part
Assembly
Subassemblies
Finished product
Inventory or shipping

SOURCE Office of Technology Assessment

Source: Reprinted from Computerized Manufacturing Automation: Employment, Education and the Workplace, Office of Technology Assessment (April 1984).

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In addition to design and development, many engineers work in testing, production, operation and maintenance. In these environments they may supervise the operation of production processes, determine causes of breakdowns, and perform tests on newly manufactured products to ensure quality control. Engineers also work in administrative and management jobs where an engineering background is necessary or in sales jobs where they explain the technical aspects of a product and assist in planning its installation or use. Engineers with advanced degrees may also teach in engineering schools of colleges and universities or work as consultants after several years of work in the field.

The major branches of the engineering profession are electrical (includes electronics), industrial, mechanical, civil, chemical, aerospace, petroleum, metallurgical and mining engineering. Generally engineers specialize in one of these fields. Since engineering problems can be extremely complex, work may cut across the traditional branches and as a result is accomplished by teaming engineering specialists with experts in other scientific, engineering or business occupations.

Engineers often use calculators and/or computers to solve mathematical equations that help specify what is needed for a device to function efficiently. They also spend a significant amount of time writing reports of their findings and consulting with others in the profession. Given the complexity of many engineering tasks/projects, individuals often are assigned to a part of the project while others supervise and coordinate the entire effort.

Most engineers work in offices and spend almost all their time at a desk. Others work in research laboratories or industrial facilities. About 50% work for manufacturing industries with the majority employed by producers of electrical and electronic equipment, aircraft and parts, machinery, chemicals, scientific instruments, primary metals, metal products and motor vehicles.

Engineers employed outside the manufacturing sector work primarily in construction, public utilities, engineering and architectural services, and business and management consultancies. The federal government is also a major employer of engineers in all fields. Although engineers are employed in every state and in urban as well as rural areas, specialists in the specific engineering fields are often concentrated in particular industries and geographic areas. (See Part I-Industry Profiles for specific high tech industries.)

Job Requirements

A bachelor's degree in engineering is the generally accepted educational requirement for beginning engineering jobs. College graduates trained in one of the natural sciences or mathematics also may qualify for some entry-level jobs. Experienced technicians with some enginnering education are occasionally able to advance to some types of engineering jobs.

Many colleges have 2-or 4-year programs leading to degrees in engineering technology. These programs prepare students for practical design and production work rather than for jobs that require more theoretical scientific and mathematical knowledge. Graduates of 4-year engineering technology programs may get jobs similar to those obtained by engineering bachelor's degree graduates. However, some employers regard them as having skills somewhere between those of a technician and an engineer.

Graduate training is essential for most beginning teaching and research positions but is not needed for the majority of other entry level engineering jobs. Many engineers obtain master's degrees, however, because an advanced degree often is desirable for promotion or is needed to keep up with new technology. Some specialties, such as nuclear or biomedical engineering, are taught mainly at the graduate level.

About 240 colleges and universities offer a bachelor's degree in engineering, and almost 70 colleges offer a bachelor's degree in engineering technology. Although programs in the larger branches of engineering are offered in most of these institutions, some small specialties are taught in only a very few. Therefore, students desiring specialized training should investigate curriculums before selecting a college. Admissions requirements for undergraduate engineering schools usually include high school courses in advanced mathematics and the physical sciences.

In a typical 4-year curriculum, the first 2 years are spent studying basic sciences--mathematics, physics, chemistry, and introductory engineering--and the humanities, social sciences, and English. The last two years are devoted, for the most part, to specialized engineering courses. Some programs offer a general engineering curriculum, permitting the student to choose a specialty in graduate school or acquire it on the job.

Some engineering curriculums require more than 4 years to complete. A number of colleges and universities now offer 5-year master's degree programs. In addition, several engineering schools have formal arrangements with liberal arts colleges whereby a student spends 3 years in a liberal arts college studying preengineering subjects and 2 years in an engineering school and receives a bachelor's degree from each.

Some schools have 5-or even 6-year cooperative plans where students coordinate classroom study and practical work experience. In addition to gaining useful experience, students can thereby finance part of their education. Because of the need to keep up with rapid advances in technology, engineers often continue their education throughout their careers.

All 50 States and the District of Columbia require licensing for engineers whose work may affect life, health, or property, or who offer their services to the public. In 1978, there were over 300,000 registered engineers. Generally, registration requirements include a degree from an accredited engineering school, 4 years of relevant work experience, and the passing of the State examination.

Engineering graduates usually begin work under the supervision of experienced engineers. Some companies have programs to acquaint new engineers with special industrial practices and to determine the specialties for which they are best suited. Experienced engineers may advance to positions of greater responsibility, and some move to management or administrative positions after several years of engineering. Some engineers obtain graduate degrees in business administration to improve their advancement opportunities, while still others obtain law degrees and become patent attorneys. Many high level executives in private industry began their careers as engineers -- this is particularly true for many high tech corporation heads.

Engineers should be able to work as part of a team and should have creativity, an analytical mind, and a capacity for detail. In addition to technical skills, it is important that engineers be able to express themselves well both orally and in writing.

Employment Opportunities

According to the Bureau of Labor Statistics (BLS) the number of engineering jobs is expected to increase about 500,000 by 1995, as the occupation is projected to grow much faster than average. As manufacturing industries, primarily durable goods, rebound from the recession and place new technologies into their production systems, there will be heavy demands for electrical, industrial, and mechanical engineers. More civil engineers will be needed to meet the demands of the rejuvenated construction industry. Petroleum engineers on the other hand should experience average growth as oil supplies stabilize and new drilling moderates.

A person considering an engineering occupation should carefully assess the demand for engineers in specific specialty areas because demand varies by field and type of employer. Other factors to consider are the stability of particular industries and the availability of research and development funds to support engineering efforts.

Competition is another factor worthy of consideration. During 1980 about 44% of those who entered engineering were recent engineering graduates. Most other entrants transferred from other occupations (generally persons with previous experience or training in engineering or a related field.) In addition science and math graduates and immigrant engineers also joined those employed as engineers.

The National Center for Education Statistics estimates that about 74,000 bachelor's degrees in engineering and engineering technology will be awarded annually through 1990. It is anticipated that about 60,000 of these graduates will enter the profession each year and thereby account for about 50% of all job openings (estimated at 120,000-136,000 per year).

It is important to note that many labor economists question the severity of shortages in engineering occupations. Their arguments are generally directed toward the statistical methodologies used to project job openings and employment. We have used BLS statistics because they represent the only consistent data we could find to use as indicators of employment growth and because they support other general findings.

Selected Engineering Specialties

These profiles cover the two key engineering professions that are most often associated with high technology industries -- electrical/electronics and industrial engineers.

Occupation: **ELECTRICAL AND ELECTRONIC ENGINEERS**

Employment, 1982 (000s)	320	
Women, % of total	4%	
Men, % of total	96%	
Median weekly earnings, 1982	$599	
Women (% of men's wages)	450	(74%)
Men	607	
Employment, 1995 (000s)	528	
% change, 1982-95	65%	

Source: U.S. Department of Labor, Bureau of Labor statistics

Job Characteristics

Electrical and electronic engineers design, develop, test, and supervise the manufacture of electrical and electronic equipment. Electrical equipment includes power generating and transmission equipment used by electric utilities, electric motors, machinery controls, and lighting and wiring in buildings, automobiles, and aircraft. Electronic equipment includes radar, computers, communications equipment, and consumer goods such as TV sets and stereo components. Electrical engineers who work with electronic equipment are usually called electronic engineers.

Electrical engineers generally specialize in a major area -- such as power distributing equipment, integrated circuits, computers, electrical equipment manufacturing, or communications -- or in a subdivision of these areas -- microwave communication or aviation electronic systems, for example. Electrical engineers design new products, write performance requirements, and develop maintenance schedules. They also test equipment, solve operating problems, and estimate the time and cost of engineering projects. Besides manufacturing and research, development, and design, many are employed in administration and management, technical sales, or teaching.

Employment Opportunities

Electrical engineering is the largest branch of engineering. The majority of these employed work for high tech industries including manufacturers of electronic and electrical equipment, aircraft and parts, business machines and professional and scientific equipment.

Employment of electrical engineers is expected to increase faster than the average for all occupations throughout the 1980s. Although increased demand for computers, communications equipment, and military electronics is expected to be the major contributor to this growth, demand for electrical and electronic consumer goods, along with increased research and development in new types of power generation, should create additional jobs. Another significant factor affecting employment is defense spending since many electrical engineering jobs are defense related. The national average salary for electrical engineers was $20,280 during 1982.

Recent projections regarding the geographic availability of electrical engineering jobs indicate that employment potential will be the best in the following states: Arkansas, Colorado, Florida, Georgia, Idaho, New Hampshire, New York, North Carolina, Oregon, South Carolina, Texas, Utah and Washington. In addition, more limited opportunities will exist in California, Indiana, Iowa, Kentucky, Michigan, New Jersey, Ohio, Pennsylvania, Virginia and West Virginia.

Occupation: **INDUSTRIAL ENGINEER**

Employment, 1982 (000s)	160	
Women, % of total	12%	
Men, % of total	88%	
Median Weekly earnings, 1982	$550	
Women (% of men's wages)	438	(77%)
Men	566	
Employment, 1995 (000s)	227	
% change, 1982-95	42%	

Source: U.S. Department of Labor, Bureau of Labor Statistics

Job Characteristics

Industrial engineers determine the most effective ways for an organization to use the basic factors of production -- people, machines, and materials. They are more concerned with people and methods of business organization than are engineers in other specialties, who generally are concerned more with products or processes, such as metals, power, or mechanics.

To solve organizational, production, and related problems most efficiently, industrial engineers design data processing systems and apply mathematical concepts (operations research techniques). They also develop management control systems to aid in financial planning and cost analysis, design production planning and control systems to coordinate activities and control product quality, and design or improve systems for the physical distribution of goods and services. Industrial engineers also conduct plant location surveys, where they look for the best combination of sources of raw materials, transportation, and taxes, and develop wage and salary administration systems and job evaluation programs. Many industrial engineers move into management positions because the work is closely related.

Employment Opportunities

During 1982 over 160,000 industrial engineers were employed and most worked in manufacturing industries. Because their skills can be used in almost any type of company, they are more widely distributed among industries than are those in other branches of engineering. For example, they work for insurance companies, banks, construction and mining firms, public utilities, hospitals, retail organizations, and government agencies. Some teach in colleges and universities. Others are independent consultants.

Employment for these engineering specialists is expected to grow faster than the average for all occupations during the 1980s. Industrial growth, more complex business operations and the greater use of automation will contribute to employment growth. Reducing costs and increasing productivity through scientific management and safety engineering should create additional opportunities. Starting salaries are in the $20,000 range.

Other Engineering Specialties

Two other occupational categories frequently paired with high technology industries are aerospace engineers and chemical engineers. Although employment is expected to grow in both fields over the next decade, the actual number of professionals will continue to remain low when compared with other occupational groups.

Aerospace Engineers

Aerospace engineers are involved in the design and solution of problems related to aircraft, satellites, missiles and space vehicles. Aeronautical or astronautical engineering tends to be more scientific than other engineering fields with an emphasis on mathematics and physics. These specialists tend to work on design teams that focus on aerodynamics, propulsion systems, structural design, materials, avionics, or stability and control systems. The majority of aerospace engineers are employed by transportation, communication and energy industries where job security is contingent on federal expenditures for defense and space programs.

Employment of aerospace engineers was about 50,000 during 1982 and projections for 1995 indicate the population of these professionals will increase beyond 60,000. Women represent less than 5% of all aeronautical and astronutical engineers. During 1982 this field commanded a high level of earnings among all engineering specialties with a median weekly wage of $630.

Chemical Engineers

Chemical engineers are involved in many phases of the production of chemicals and chemical products. They design equipment and chemical plants as well as determine methods of manufacturing products. In addition to a solid background in chemistry these professionals often must have a knowledge of physics as well as mechanical and electrical engineering.

During 1982 there were about 60,000 chemical engineers with employment estimated to reach 80,000 by 1995. Fewer than 10% of those employed in 1982 were women. The median wage for chemical engineers was $630 per week.

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The other major engineering specialties -- mechanical, civil, and petroleum -- have also been influenced by advances in technology but are not as prevalent in high tech industries. Information about these occupations can be found in the Department of Labor's Occupational Outlook Handbook and other similar sources.

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Occupation: **ENGINEERING and SCIENCE TECHNICIANS (all fields)**

Employment, 1982 (000s)	1,243	
Women, % of total	17%	
Men, % of total	83%	
Median weekly earnings, 1982	$399	
Women (% of men's wages)	307	(78%)
Men	394	
Employment, 1995 (000s)	1,661	
% change, 1982-95	34%	

Source: U.S. Department of Labor, Bureau of Labor Statistics

Job Characteristics

Knowledge of science, mathematics, industrial machinery, and technical processes enables engineering and science technicians to work in all phases of business and government -- from research and design to manufacturing, sales, and customer service. Although their jobs are more limited in scope and more practically oriented than those of engineers or scientists, technicians often apply the theoretical knowledge developed by engineers and scientists to actual situations. Technicians frequently use more complex electronic and mechanical instruments, experimental laboratory equipment, and drafting instruments. Technicians must be able to use technical handbooks and calculators, and many work with computers.

In research and development, one of the largest areas of employment of engineering and science technicians, these workers set up experiments and calculate the results, often with the aid of computers. They also assist engineers and scientists in developing experimental equipment and models by making drawings and sketches and, frequently, by doing routine design work.

In production, technicians usually follow the plans and general directions of engineers and scientists, but often without close supervision. They may prepare specifications for materials, devise tests to insure product quality, or study ways to improve the efficiency of an operation. They often supervise production workers to make sure they follow prescribed plans and procedures. As a product is built, technicians check to see that specifications are followed, keep engineers and scientists informed on progress, and investigate production problems.

As sales workers or field representatives for manufacturers, technicians give advice on installation and maintenance of complex machinery, and may write specifications and technical manuals. Technicians may work in engineering, physical science, or life science. Within these general fields, job titles may describe the level (biological aide or biological technician), duties (quality control technician or time study analyst), or area of work (mechanical, electrical, or chemical).

Scientific and engineering technicians work under a varity of conditions depending upon their field of specialty and employer. The majority work regular hours in laboratories and industrial facilities. During 1982 employment in these occupations grew to 1,243,000.

The overwhelming majority of technicians work in private industry with most employed by manufacturers. Among the largest industrial employers are the electrical equipment, chemical, machinery and aerospace industries. In nonmanufacturing many technicians are in wholesale trade, communications and in the engineering and architectural service industries. In addition, the federal government employs technicians primarily as engineering and electronics technicians, biological technicians, meteorological technicians, and physical science technicians. The largest number work for the Department of Defense while others work for the Interior and Commerce Departments.

Job Requirements

Although persons can qualify for technician jobs through many combinations of work experience and education, most employers prefer applicants who have had some specialized technical training. Specialized training is available at technical institutes, junior and community colleges, extension divisions of colleges and universities, and public and private vocational-technical schools. A few engineering and science students who have not completed the bachelor's degree and others who have degrees in science and mathematics also are able to qualify for technician positions.

Persons also can qualify for technician jobs by less formal methods. Workers may learn through on-the-job training, apprenticeship programs, or correspondence schools. Some qualify on the basis of experience gained in the Armed Forces. However, postsecondary training is becoming increasingly necessary for advancement to more responsible jobs.

Some of the types of postsecondary and other schools that provide technical training are discussed in the following paragraphs:

Technical Institutes. Technical institutes offer training to qualify students for a job immediately after graduation with a minimum of on-the-job training . In general, students receive intensive technical training but less theory and general education then they would in engineering schools or liberal arts colleges. As few technical institutes and community colleges offer cooperative programs in which students spend part of the time in school and part in paid employment related to their studies. Such practical work experience can be a decided advantage when seeking full-time employment as an engineering or science technician.

Junior and Community Colleges. Curricula in junior and community colleges which prepare students for technician occupations are similar to those in technical institutes but emphasize theory and liberal arts. After completing the 2-year programs, some graduates qualify for technician jobs while others continue their education at 4-year colleges.

Area Vocational-Technical Schools. These postsecondary public institutions serve students from surrounding areas and emphasize training in skills needed by employers in the local area. Most require a high school degree or its equivalent for admission.

Other Training. Some large corporations conduct training programs and operate private schools to meet their needs for technically trained personnel in specific jobs; such training rarely includes general studies. Training for some technician occupations, for instance tool designers and electronic technicians, is available through formal 2- to 4-years apprenticeship programs. The apprentice gets on-the-job training under the close supervision of an experienced technician and related technical knowledge in classes, usually conducted after working hours.

Many private technical and correspondence schools often specialize in a single field of technical training, such as electronics. Some of these schools are owned and operated by large corporations that have the resources to provide up-to-date training in a technical field.

Those interested in a career as a technician should have an aptitude for mathematics and science and enjoy technical work. An ability to do detailed work with a high degree of accuracy is necessary; for design work, creative talent also is desirable. Technicians are part of a scientific team, and often work closely with engineers and scientists as well as other technicians and skilled workers. Some technicans, such as repair and maintenance technicians, should be able to work independently and to deal effectively with customers. Because technicians work with various tools and equipment, manual dexterity also is important.

Engineering and science technicians usually begin work as trainees in routine positions under the direct supervision of an experienced technician, scientist, or engineer. As they gain experience, they receive more responsibility and carry out a particular assignment under only general supervision. Technicians may eventually move into supervisory positions.

Employment Opportunities

According to the Bureau of Labor Statistics, electrical and electronic technicians and mechanical engineering technicians should experience strong growth similar to their engineering counterparts. In fact, both of the above technician categories are considered by BLS to be among the 20 fastest growing occupations during the period 1982-1995.

In general, industrial expansion, the increasing complexity of technology, and the growing importance of other areas of scientific research will contribute to increased employment of engineering and scientific technicians. The majority of job openings will result, however, from the need to replace experienced technicians who change jobs or leave the workforce. Many such as electricial and electronic technicians possess skills that allow them to transfer to other types of jobs. The near majority of recent entrants to the ranks of engineering and scientific technicians had some post secondary education. Opportunities are best for graduates of training programs in which students gain practical experience. Many college graduates in engineering and related disciplines (e.g. science majors) also compete for these positions with a greater likelihood of being hired than those with less education. Just as engineers and related workers are affected by changes in the economic climate that influence employment, engineering and scientific technicians are also sensitive to cyclical swings in the economy.

Starting salaries for graduates of two-year post secondary programs are in the $12,000 range and senior technicians average about $22,000 a year. Engineering technicians salaries are generally higher than those specializing in scientific fields.

Selected Technician Occupations

These brief profiles provide general descriptions of specialty areas within the engineering and science technician group of occupations that are characteristic of high tech employment.

Occupation: **ELECTRICAL and ELECTRONIC TECHNICIANS**

Employment, 1982 (000s)	366	
Women, % of total	12%	
Men, % of total	88%	
Median weekly earnings, 1982	$400	
Women (% of men's wages)	312	(76%)
Men	411	
Employment, 1995 (000s)	589	
% change, 1982-95	61%	

Source: U.S. Department of Labor, Bureau of Labor Statistics

Technicians in this field develop, manufacture, and service electronic equipment and systems. The types of equipment range from radio, radar, sonar, and television to industrial and medical measuring or control devices, navigational equipment, and computers. Because the field is so broad, technicans often specialize in one area, such as automatic control devices or electronic amplifiers. Furthermore, technological advances are constantly opening up new areas of work such as integrated circuit technology.

When working in design, production, or customer service, electronic technicians use sophisticated measuring and diagnostic devices to test, adjust, and repair equipment. In many cases, they must understand the field in which the electronic device is being used. To design equipment for space exploration, for example, a technician must consider the need for minimum weight and volume and maximum resistance to shock, extreme temperature, and pressure. Some electronics technicians also work in technical sales, while others work in the radio and television broadcasting industry.

As indicated previously, employment is expected to grow faster than most other occupations. Recent indicators suggest that the best job opportunities will be in the states indicated under the section covering electrical engineers.

Industrial Engineering Technicians

Technicians in this area, usually called industrial production technicians, assist industrial engineers on problems involving the effect use of personnel, materials, and machines to produce goods and services. They prepare layouts of machinery and equipment, plan the flow of work, make statistical studies, and analyze production costs. Industrial engineering technicians also conduct time and motion studies (analyze the time and movements a worker needs to accomplish a task) to improve the production methods and procedures in manufacturing plants.

Many industrial engineering technicians acquire experience that enables them to qualify for other jobs. For example, those specializing in machinery and production methods may move into industrial safety. Others, in job analysis, may set job standards and interview, test, hire, and train personnel. Still others may move into production supervision.

Aeronautical Technicians

In this area, the technician works with engineers and scientists to design and produce aircraft, rockets, guided missiles, and spacecraft. Many aid engineers in preparing design layouts and models of structures, control systems, or equipment installations by collecting information, making computations, and performing laboratory tests. For example, a technician might estimate weight factors, centers of gravity, and other items affecting load capacity of an airplane or missile. Other technicians prepare or check drawings for technical accuracy, practicability, and economy.

Aeronautical technicians frequently work as manufacturers' field service representatives, serving as the link between their company and the military services, commerical airlines, and other customers. Technicians also prepare technical information for instruction manuals, bulletins, catalogs, and other literature.

Instrumentation Technicians

Automated manufacturing and industrial processes, oceanographic and space exploration, weather forecasting, satellite communication systems, environmental protection, and medical research have helped to make instrumentation technology a fast-growing field. Technicians help develop and design complex measuring and control devices such as those in a spacecraft that sense and measure changes in heat or pressure automatically record data, and make necessary adjustments. These technicians have extensive knowledge of physical sciences as well as electrical-electronic and mechanical engineering.

OCCUPATION: DRAFTER

Employment, 1982 (000s)	302	
Women, % of total	17%	
Men, % of total	83%	
Median weekly earnings, 1982	365	
Women (% of men's wages)	304	(80%)
Men	379	
Employment, 1995 (000s)	318	
% change, 1982-95	5%	

Source: U.S. Department of Labor, Bureau of Labor Statistics

Job Characteristics

Drafters prepare detailed drawings based on rough sketches, specifications, and calculations made by scientists, engineers, architects, and designers. They also calculate the strength, quality, quantity and cost of materials. Final drawings contain a detailed view of the object from all sides as well as specifications for materials to be used, procedures followed and other information to carry out the job.

Drafters use compasses, dividers, protractors, triangles and other drafting tools to prepare drawings. They also use technical handbooks, tables, and calculators to help solve problems. Drafters increasingly use computer aided design (CAD) systems and other electronic drafting equipment to perform drafting tasks. Drafters usually specialize in a particular field of work such as mechanical, electrical, aeronautical, structural or architectural drafting.

Job Requirements

Employers prefer applicants for drafting positions who have acquired training in technical institutes, junior and community colleges, extension divisions of universities, and vocational and technical high schools. Others qualify through on-the-job training programs combined with part-time schooling or through 3 to 4-years apprenticeship programs.

Training for a career in drafting, whether in a high school or post-high school program, should include courses in mathematics, physical sciences, mechanical drawing, and drafting. Shop practices and shop skills also are helpful since most higher level drafting jobs require knowledge of manufacturing or construction methods. Many technical schools offer courses in structural design, architectural drawing, and engineering or industrial technology.

Those planning careers in drafting should be able to do freehand drawings of three-dimensional objects and also detailed work requiring a high degree of accuracy. They should have good eyesight and manual dexterity. In addition, they should be able to function as part of a team since they work directly with engineers, architects, designers, and other workers. Artistic ability is helpful in some specialized fields.

Employment Opportunities

Engineering and architectural firms have traditionally been the largest employers of drafters though many of these technicians work for durable goods manufacturers including electrical and electronic equipment and goods producers. A small portion of these workers are employed by state and local government agencies, educational institutions and nonprofit organizations.

Although recent federal government employment projections indicate little or negative growth for drafters over the next few years, predictions made by futurists indicate that one new occupation related to drafting -- computer-aided design (CAD) technician -- will provide over 250,000 future jobs.

At present it appears that holders of an associate degree in drafting and persons who are trained in the use of computer-aided drafting systems and electronic drafting equipment will have the best prospects for employment. Many large employers already require post-secondary technical education, though well-qualified high school graduates who have studied drafting may find opportunities in some types of jobs. Photoreproduction of drawings and the expanding use of electronic drafting equipment and computers, however, will reduce the need for less skilled drafters.

Drafters are highly concentrated in industries that are sensitive to cyclical swings in the economy such as engineering and architectural services and durable goods manufacturing. During an economic recession, drafters may be laid off as fewer products are designed, less research and development work is done, and fewer drafting services are needed.

Other occupations is which workers are required to prepare or understand detailed drawing, make accurate and precise calculations and measurements, and use various measuring devices include architects, engineering technicians, engineers, landscape architects, photogrammetrists, and surveyors.

Production Occupations

The primary jobs associated with high tech production work are operative positions such as assemblers, processors, and fabricators and craft positions such as testers and inspectors. Workers in these and related occupations represent the blue collar work force in high tech and other manufacturing industries along with machinists, metal workers, tool and die markers, maintenance workers, materials handlers, stock clerks and other plant personnel.

The profiles in this section cover selected operative and craft positions associated with electronics manufacturing. While we've attempted to provide specific information for each job category keep in mind that job titles and responsibility levels may vary among individual employers. Plant size (in terms of the number of workers) can also influence job content and advancement to higher skilled production jobs.

Occupation: **ELECTRICAL AND ELECTRONIC ASSEMBLERS**

Employment, 1982 (000s)	286,000	
Women, % of total	70%*	
Men, % of total	30%*	
Median weekly earnings, 1982	$245	
Women (% of men's wages)	220*	(70%)*
Men	320*	
Employment, 1995 (000s)	362,000	
% change, 1982-95	27%	

* WOW estimates

Source: U.S. Dept. of Labor,Bureau of Labor Statistics

Job Characteristics

Production workers who put together parts of manufactured products are called "assemblers". Assemblers usually work as part of a large production team on one component of a product with many workers contributing to a single finished product. Most assemblers in electronics industries work at tables while seated as opposed to assemblers in other types of manufacturing who work on production lines or put together heavy equipment on shop floors.

Trainees in electronics assembly begin by performing routine tasks in support of electronic or electro-mechanical assembly operations such as cutting wire to specified sizes, stripping or bending wires, and wiring and fastening terminal connectors. Tools including soldering irons, wire strippers, crimpers, wrenches, screwdrivers and pliers are among those used to perform these tasks.

After mastering the basic techniques and routines, the worker begins to perform subassembly or assembly operations of a repetitive nature to build up and assemble routine units such as printed circuit boards, modules, chassis drawers, cable harnasses and simple electronic subassemblies. Preparatory tasks such as wire cutting, etc. may also be required. In order to perform these tasks the worker follows blue prints, wire lists, diagrams and other shop procedures.

There are often three or four levels on the assembler career ladder beyond the entry-level trainee position. Advancement leads to more difficult skill levels, less supervision and more responsibility. Accuracy in computational skills as well as assembly of complex components become key factors in this progression. The most competent assemblers may eventually move onto supervisory positions in assembly operations or become prototype assemblers. Prototype assemblers work from rough schematics, blue prints and for verbal instructions to construct and assemble a variety of developmental assemblies, subassemblies or component parts. Assembly experience can also prepare the worker for other production jobs, product repair and related alternatives both in and outside of the company.

Assembly work is often monotonous because of its repetitive nature -- a worker may perform the same task 200 times a day -- and stressful -- working with small electronic components (sometimes using microscopes) in a fast and accurate manner following a complex series of steps toward the objective of achieving a daily quota can cause eyestrain and related discomfort. Work stations vary depending on the environment needed for a particular component or assembly. Some firms offer flextime and many large facilities operate on shifts.

Job Requirements

Employers seek workers who can do routine work at a fast pace. A high school diploma is preferred but not always required. For some types of assembly jobs applicants may have to meet special requirements. Good eyesight, with or without glasses, may be required for assemblers who work with small parts. Applicants are often tested for color blindness by electrical and electronics firms since products may contain many different colored wires.

Although inexperienced people can be trained to do most assembly work in a few days or weeks, electronics employers often seek trainees that can perform simple computations, understand the basic principles of electricity and electronics and are familiar with the tools used in production work. A sound background in mathematics and electronics also enhances employees opportunities to advance within the occupational group, or move to other production jobs or onto more skilled trades.

Employment Opportunities

Projections prepared by the federal government indicate that employment of all assemblers (including those in electrical and electronics industries) will grow over the next decade. The job outlook for assemblers, however, will vary with the success of the industries in which they are employed and the general economic climate -- during the recession many production workers experienced layoffs including those in high tech industries.

Job opportunities for electronics assemblers as well as production workers in other durable goods manufacturing industries may also be influenced by the loss of jobs to automation or overseas employment. Although the boom in microelectronics technology is creating a significant increase in demand for electronic products, many new plants are being designed and constructed to use automated machine or robot assembly systems. The initial installations of automated equipment have been introduced to production lines for large products such as washing machines and automobiles but greater attention is now being focused on smaller products and components. The cost consciousness of many high tech manufacturers has also led to an increase in assembly activity outside the U.S. in areas where labor is paid less.

Geographic location also influences job opportunities for assemblers. At present it appears that the greatest growth will occur in high tech manufacturing states such as California, Massachusetts, Texas and Arizona as well as selected traditional manufacturing states like Illinois, New Jersey and Pennsylvania.

Electronics assemblers earn from $4 to $5 per hour as trainees and $6 to $8 hours when more experienced. The national average salary was about $12,000 in 1983. Supervisory salaries are in the $15,000 to $20,000 range. The majority of electronics assemblers (and other production workers) employed by high tech companies are not members of labor unions.

Selected Production Occupations

Descriptions of the vast number of production occupations associated with microelectronics manufacturing alone is beyond the scope of this report. As a result, WOW has selected a few occupational classifications from the semiconductor and computer industries to provide examples of the kinds of jobs associated with high tech manufacturing industries. The employment outlook for these jobs is comparable to that for electronics assemblers.

Semiconductor Processor

Semiconductor processors carry out a variety of tasks associated with the processing of wafers used in the manufacture of semiconductors (chips). Specialtly areas include cleaning, polishing, baking, scribing, masking, aligning, or spinning wafers. Frequently, processors learn one function and when they become proficient move to learn another stage of processing. As new production methods are developed, more processing functions are being mechanized or automated and consequently processors jobs involve the operation and monitoring of the processing equipment.

These jobs require good vision and eye-to-hand coordination, manual dexterity, alertness and patience since tasks are repetitive and work is usually performed under a micropscope. Depending upon the stage of processing workers may be required to sit or stand for long periods of time or work with acids and chemicals. Shift work is common and turnover is high in this occupation. Semiconductor processors start at $4 - $6 per hour and experienced workers earn as much as $8 per hour.

Semiconductor Assembler

Workers in this category assemble semiconductor devices from written and oral instructions by positioning and attaching semiconductor chips in alignment with other parts. Hand tools, microscopes, and bonding and welding machines are used to perform these tasks. The assembler also cleans the devices using solvents or electrosnic equipment.

Educational requirements for these jobs are minimal but employers do seek applicants who have good vision and manual dexterity as well as patience and attentiveness to carry out repetitive, microscopic tasks over extended periods of time. In addition assemblers need to be free of chemical allergies for certain assembly stages. Entry-level semiconductor assemblers' wages start at about $4-5 per hour and increase to around $7 with experience. Another similar job category is micro assembler which involves the assembly of miniaturized components.

Electro-Mechanical Fabricator

Fabricators work from production blue prints, wiring diagrams, parts lists, wire lists, sketches and oral isntructions to perform many mechanical and electro-mechanical assembly and fabrication operations. This job requires the use of simple hand and power tools such as drills, wrenches, screwdrivers, soldering irons, pliers, taps, brazing torches, etc. Work tasks generally involve building up sub-assemblies, mounting parts and assemblies such as panels, pulleys, gears, switching mechanisms, control mechanisms, power supplies and so on.

Employers generally seek applicants with as least a high school degree or equivalent with abilities to understand and perform simple shop mathematics and measurements. Previous experience in using power and hand tools is also often a prerequisite. In many cases fabricators who are hired have post-secondary electro-mechanical training although in-house advancement may occur for electronics assemblers with the required skills. Wages are comparable to experienced assemblers and other operatives.

Electronics Tester

Electronics testers perform a variety of tests on electronic assemblies, components and parts using standard test equipment and procedures. These jobs require the ability to work from manuals and schematic designs, knowledge of components, wire sizes and color codes. They also require skill in the use of oscilliscopes, voltmeters, ohmmeters, ammeters, and standard hand tools. Manual dexterity, good vision and color perception are also necessary.

Most employers seek applicants with experience in testing digital, microwave, or analog parts and products. One or more years of technical training is generally required for electronic testers although many assemblers advance to these positions. In fact, job opportunities are best for those with related assembly experience since many employers prefer to promote in-house workers. Entry-level wages start at $5 to $6 per hour and increase to as much as $9.50 per hour for the most experienced testers.

Electronics Assembly Inspector

These workers inspect developmental and/or production electronic assemblies or subassemblies for conformance with quality assurance standards and applicable specifications. Their work generally involves the use and interpretation of blue prints, engineering documents, established operating procedures and other instructions. Inspections include an examination for compliance with workmanship standards and proper installation of correct components and wiring. Based upon their evaluation, inspectors accept, reject or order re-work of an item and prepare reports as well as maintain records.

Most electronics inspectors gain their positions through in-house experience since familiarity with the employer's products, procedures and standards is a critical job component. While this type of job can be an opportunity for a production operative such as an assembler, the job may require higher mathematical skills, facility with testing instruments and interpretative skills that come from additional vocational training.

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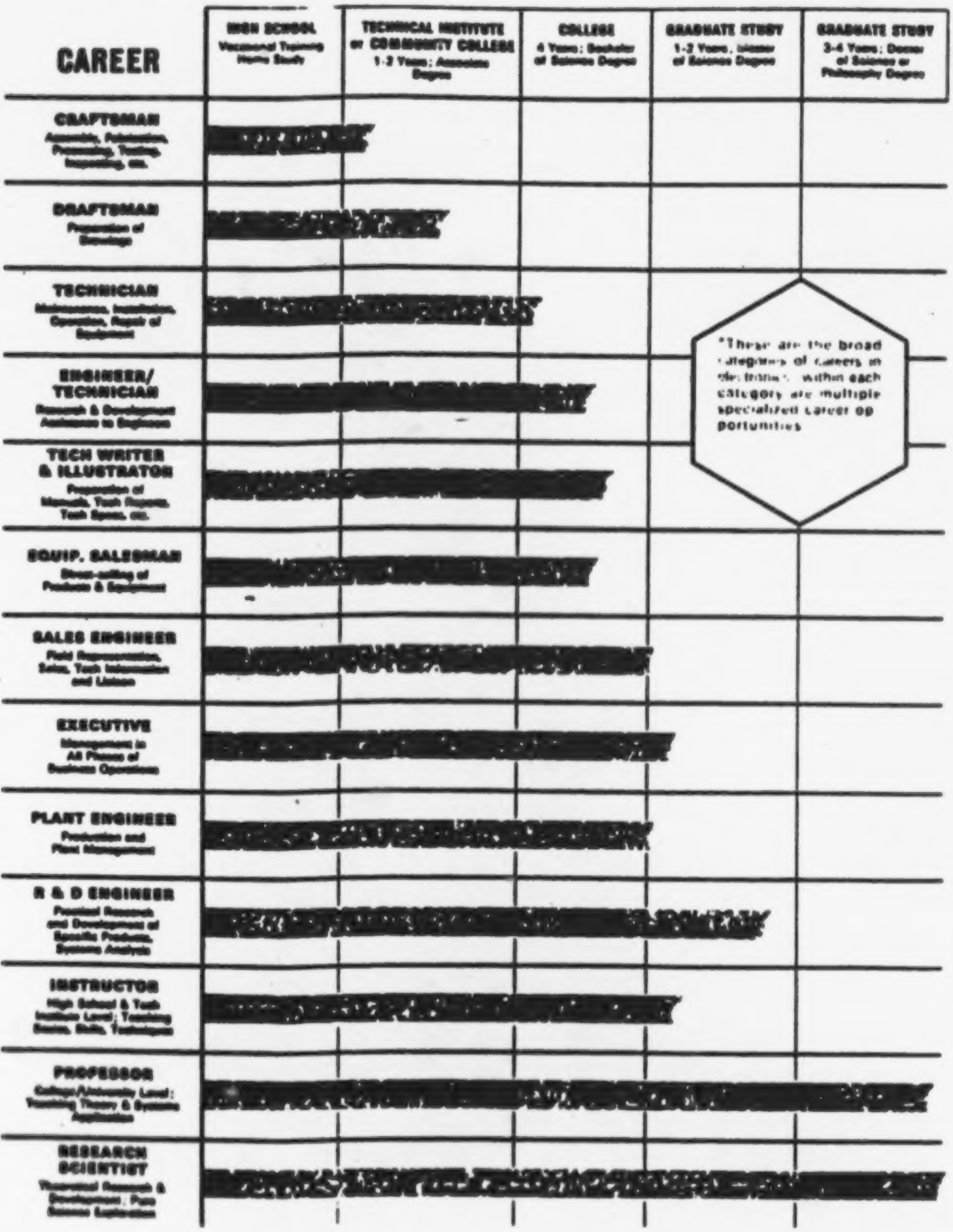
Table I-A summarizes the educational requirements for careers in electronics.

TABLE I-A.

EDUCATIONAL REQUIREMENTS FOR CAREERS IN ELECTRONICS



Source: Reprinted from "Planning a Career in Electronics",
Electronic Industries Association, Washington, D.C.

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SECTION II. COMPUTER OCCUPATIONS

This section covers the major occupational groups associated with data processing activities -- from data entry clerks to systems analysts. Also included in this section is a profile of computer service technicians.

Occupation: **SYSTEMS ANALYST (Computers)**

Employment, 1982 (000s)	254	
Women, % of total	26%	
Men, % of total	74%	
Median weekly earnings, 1982	$539	
Women (% of men's wages)	428	(75%)
Men	568	
Employment, 1995 (000s)	471	
% change, 1982-95	85%	

Source: U.S. Department of Labor,
Bureau of Labor Statistics

Job Characteristics

Many essential business functions and scientific research projects depend on systems analysts to plan efficient methods of processing data and handling the results. Analysts begin an assignment by discussing the data processing problem with managers or specialists to determine the exact nature of the problem and to break it down into its component parts. If a new inventory system is desired, for example, systems analysts must determine what new data must be collected, the equipment needed for computation,and the steps to be followed in processing the information.

Analysts use various techniques, such as cost accounting, sampling, and mathematical model building to analyze a problem and devise a new system. Once a system has been developed, they prepare charts and diagrams that describe its operation in terms that managers or customers can understand. They also may prepare a cost-benefit analysis to help the client decide whether the proposed system is satisfactory.

If the system is accepted, systems analysts translate the logical requirements of the system into the capabilities of the computer machinery or "hardware." They also prepare specifications for programmers to follow and work with them to "debug," or eliminate errors from the system.

The problems that systems analysts solve range from monitoring nuclear fission in a powerplant to forecasting sales for an appliance manufacturing firm. Because the work is so varied and complex, analysts usually specialize in either business or scientific and engineering applications.

Some analysts improve systems already in use by developing better procedures or adapting the system to handle additional types of data. Others do research, called advanced systems design, to devise new methods of systems analysis.

Job Requirements and Advancement

There is no universally acceptable way of preparing for a job as a systems analyst because employers' preferences depend on the work being done. However, college graduates generally are sought for these jobs, and, for some of the more complex jobs, persons with graduate degrees are preferred. Employers usually want analysts with a background in accounting, business management, or economics for work in a business environment while a backgound in the physical sciences, mathematics, or engineering is preferred for work in scientifically oriented organizations. A growing number of employers seek applicants who have a degree in computer science, information science, information systems, or data processing. Regardless of college major, employers look for people who are familiar with programming languages (e.g. COBOL, FORTRAN, etc.). Courses in computer concepts, systems analysis, and data base management systems offer good preparation for a job in this field.

Prior work experience is important. Nearly half of all persons entering this occupation have transferred from other occupations, especially from computer programmer. In many industries, systems analysts begin as programmers and are promoted to analyst positions after gaining experience.

Systems analysts must be able to think logically and should like working with ideas. They often deal with a number of tasks simultaneously. The ability to concentrate and pay close attention to detail also is important. Although systems analysts often work independently, they also work in teams on large projects. They must be able to communicate effectively with technical personnel, such as programmers, as well as with clients who have no computer background.

In order to advance, systems analysts must continue their technical education. Technological advances come so rapidly in the computer field that continuous study is necessary to keep skills up to date. Training often takes the form of 1- and 2-week courses offered by employers and "software" vendors. Additional training may come from professional development seminars offered by professional computing societies.

An indication of experience and professional competence is the Certificate in Data Processing (CDP). This designation is conferred by the Institute for Certification of Computer Professionals upon candidates who have completed 5 years' experience and passed a five-part examination.

In large data processing departments, persons who begin as junior systems analysts may be promoted to senior or lead systems analysts after several years of experience. Systems analysts who show leadership ability also can advance to jobs as managers of systems analysis or data processing departments.

Employment Opportunities

Opportunities for systems analysts are expected to be excellent over the coming decade based on expanded computer usage, increased computer capabilities and new applications of computer technology. Employment has been projected to reach nearly one-half million by 1995 with opportunities in a wide variety of employment settings. Systems analysts will be likely to find jobs in computer service companies, accounting firms, research and development organizations, computer manufacturing and a host of other businesses. Sophisticated accounting systems, telecommunications networks and scientific research are just a few of the areas where the use of computer systems has resulted in new approaches to problem solving.

Advances in technology that have drastically reduced the size and cost of computer hardware will have differing effects on employment of systems analysts. Employment in data processing firms may not grow quite as rapidly as in recent years as more small businesses install their own computers rather than rely on a data processing service. This will be offset, however, by a rising demand for analysts to design systems for small computers that are specifically adapted to meet problem-solving needs of individual businesses.

Graduates of computer-related curriculums should enjoy the best prospects for employment. College graduates who have had courses in computer programming, systems analysis, and other data processing areas should also find many opportunities. Persons without a college degree and college graduates unfamiliar with data processing will face competion from the growing number of experienced workers seeking jobs as systems analysts.

Employment potential should be good for systems analysts in most states. During 1980 these professionals were concentrated in two geographic regions -- about 33% were employed in the Midwest and 25% in the Northeast. At that time the majority of these computer specialists worked in urban areas for manufacturing firms, government agencies, wholesale businesses, data processing service organizations, banks and insurance companies.

Salaries for systems analysts vary depending on experience, type of employment, size of employer and geographic location. According to a recent Datamation survey of data processing salaries, junior systems analysts earn an average of $18,700 and senior systems analysts command salaries averaging over $32,000. (See **Table II-A** at the end of this section for additional detail.)

Occupation: **COMPUTER PROGRAMMER**

Employment, 1982 (000s)	266	
Women, % of total	32%	
Men, % of total	68%	
Median weekly earnings, 1982	$444	
Women (% of men's wages)	382	(80%)
Men	478	
Employment, 1995 (000s)	471	
% change, 1982-95	77%	

Source: U.S. Department of Labor,
Bureau of Labor Statistics

Job Characteristics

Programmers prepare sets of detailed, coded instructions (called "programs" or "software") which tell computers the steps to be followed to organize and process information. There are two major kinds of programmers -- applications and systems programmers.

Applications programmers develop software for specific data processing applications e.g. business or commercial programmers are concerned with applications such as payroll or inventory control. Engineering and scientific programmers prepare programs for solving engineering, scientific and mathematical problems. Applications programmers write instructions for the computer in "high level" programming languages such as COBOL (for business applications) and FORTRAN (for scientific and engineering applications).

Systems programmers are concerned with systems software -- the basic programs such as operating systems and compilers that control and coordinate the operation of the computer system itself, enabling it to read, interpret and execute the applications software. Systems programmers write computer instructions in machine or assembly languages. Some systems programmers are called "software engineers" because they design and develop new systems software. The latter group are employed primarily by computer manufacturers. Other systems programmers (who work for computer users) install, maintain and modify the systems software to fit specific company needs.

Programmers are not only responsible for writing sets of instructions for computers but also for testing their programs for potential errors and "debugging" them. Although simple programs can be prepared in a few hours, programs that use complex mathematical formulas or many data files may require more than a year of work. Programmers who work for large organizations with complex data processing needs and other computer tasks often work as teams under a senior programmer's supervision. Although programmers generally work a standard 40-hour work week, many work irregular hours and during weekends depending on their access to the computer system.

Job Requirements and Advancement

There are no universal training requirements for programmers because employers needs vary. Most programmers are college graduates; others have taken special courses in computer programming to supplement their experience in fields such as accounting or inventory control.

Employers using computers for scientific or engineering applications prefer college graduates who have degrees in computer or information science, mathematics, engineering, or the physical sciences. Graduate degrees are required for some jobs. Very few scientific organizations are interested in applicants who have no college training.

Most employers prefer business programmers to have a bachelor's degree in computer science or in business, with data processing courses. Some employers of business programmers do not require college degrees, but hire applicants who have had college courses in data processing, and are experienced in computer operation or payroll accounting; those selected, however, need additional data processing courses to become fully qualified programmers. Although it may be preferred, prior work experience in the past has not been essential for a job as a programmer; in fact, about half of all entrants to the occupation in 1981 had little or no work experience.The opportunities for applicants without programming coursework or experience will diminish, however, as more job seekers attain these skills.

Computer programming is taught at public and private vocational schools, community and junior colleges, and universities. Instruction ranges from introductory home study courses to advanced courses at the graduate level. High schools in many parts of the country also offer courses in computer programming.

An indication of experience and professional competence at the senior programmer level is the Certificate in Computer Programming (CCP). This designation is conferred by the Institute for Certification of Computer Professionals upon candidates who have passed a basic five-part examination. In addition, individuals may take another section of the exam in order to specialize in business, science, or systems applications.

In hiring programmers, employers look for people who can think logically and are capable of exacting analytical work. The job calls for patience, persistence, and the ability to work with extreme accuracy even under pressure. Ingenuity and imagination are particularly important when programmers must find new ways to solve a problem.

Beginning applications programmers usually spend their first weeks on the job attending training classes. After this initial instruction, they work on simple assignments while completing further specialized training programs. Programmers generally must spend at least several months working under close supervision before they can handle all aspects of their job. Because of rapidly changing technology, programmers must continue their training by taking courses offered by their employer and software vendors. For skilled workers, the prospects for advancement are good. In large organizations, they may be promoted to lead programmers and be given supervisory responsibilities. Some applications programmers may become systems programmers. Both applications programmers and systems programmers often become systems analysts or are promoted to managerial positions.

Employment Opportunities

Occupational projections for the future indicate continued growth for computer programmers over the next few years. During recent years there has been a shortage of trained computer professionals which has opened job opportunities to persons with the requisite educational requirements as well as computer operating personnel who have completed additional training. High wages for programmers have also attracted other workers with appropriate skills such as mathematics and physics teachers and engineers.

The demand for applications programmers will increase as many more processes once done by hand are automated, but employment is not expected to grow as rapidly as in the past. Improved software, such as utility programs that can be used by other than data processing personnel, will simplify or eliminate some programming tasks. More systems programmers will be needed to develop and maintain the complex operating programs made necessary by higher level computer languages, as well as to link or coordinate the output of different computer systems.

Job prospects should be excellent for college graduates who have had computer-related courses, particularly for those with a major in computer science or a related field. The number of persons with computer skills is not expected to keep pace with rising demand. Graduates of 2-year programs in data processing technologies also should have good prospects, primarily in business applications. Given the growing and wide spread use of computers, job opportunities are likely to be good in major employment centers of most states. During 1983 starting salaries for computer programmers ranged from $18,000 to $24,000. Systems programmers generally earn more than applications programmers. (See **Table II-A** at the end of this section for further detail.)

COMPUTER OPERATING PERSONNEL

All data systems require specialized workers to enter data and instructions, operate the computer, and review the results. The data to be processed and the instructions for the computer are called "input", the results usually are called "output". Workers in these job categories work for organizations with large computer systems (mainframes) that are used for internal business activities or to provide data processing services for others.

Occupation: **DATA ENTRY OPERATOR**

Employment, 1982 (000s)	320	
Women, % of total	94%	
Men, % of total	6%	
Median weekly earnings, 1982	$240	
Women (% of men's wages)	237	(63%)
Men	372	
Employment, 1995 (000s)	286	
% change, 1982-95	(11%)	

Source: U.S. Department of Labor
Bureau of Labor Statistics

Job Characteristics

Information is entered into a computer system by data entry personnel in a variety of ways. **Data entry operators** (also known as data-entry clerks) prepare data for computer processing and storage. Operators use special alphanumeric key boards to transcribe information from source documents into "machine-readable" form. **Key punch operators** use machines which encode data by punching patterns of holes into cards or paper tape. Key-to-tape and key-to-disk operators use equipment similar to key punch machines to transcribe data onto magnetic tapes or disk packs. With all key-entry systems the emphasis is on rapid production of a heavy volume of work. The output is checked by experienced operators on another (verifier) machine.

A different group of workers actually enters the data into the computer. Unlike key-entry operators, **terminal (CRT) operators** type from source documents directly into the computer, using the computer terminal key board. These workers check their own work on the terminal viewing screen, make the necessary corrections and then immediately transmit the data to the central computer. With this direct data entry, the emphasis is more on accuracy than speed. Some CRT operators do other clerical tasks such as typing, filing, answering phones or perform simple computer functions.

Advancement opportunities for data entry operators are limited because entry techniques are becoming more specialized. A few go on to become computer operators with additional training.

Occupation: **COMPUTER OPERATOR**

Employment, 1982, (000s)*	260	
Women, % of total	62%	
Men, % of total	38%	
Median weekly earnings, 1982	285	
Women (% of men's wages)	252	(71%)
Men	354	
Employment, 1995 (000s)*	451	
% change, 1982-95	73%	

*Includes peripheral EDP equipment operators.

Source: U.S. Department of Labor,
Bureau of Labor Statistics

Job Characteristics

Computer operators are the workers who actually run the computer when it performs data processing or other tasks. Following instructions for each job, operators load the input (tapes, disks, etc.), make certain the output unit has the material it needs, clear the system and begin the operation. While a job is being handled by the computer the computer operator monitors the activity by watching the equipment (console) for signals that may indicate malfunctions. If the computer stops or an error is indicated the operator is responsible for locating the problem, and taking corrective action.

In large data processing operations there may be a senior operator tending the central console, assisted by other operators who change tapes or disks and check other peripheral equipment. In newer, more complex installations, computers may run many programs at one time. In such an installation, when an error or equipment failure occurs, much more is demanded of the operator where actions may affect many programs.

Console operators must adapt the computer to the program and therefore must know the capability of the machine as well as how to change circuit boards or chips for individual programs. Operators must also know what to do if equipment breaks down and which manuals to consult for each job. These employees also maintain records of computer usage and prepare reports covering its operation. The occupation thus requires mechanical skills as well as reasoning ability.

Computer operators often start as **peripheral equipment operators.** These workers support computer operations by loading input (tapes, disks, punched cards) and tending output devices such as disk drives and high speed printers. As they gain experience and can obtain additional training, operators advance to console operator, lead operator and supervisory positions. Occasionally computer operating personnel go on to become programmers based on additional education and training (usually at their own expense). Computer and peripheral equipment operators work in well-ventilated, temperature controlled environments. Air conditioning counteracts the heat generated by machine operations and noise levels can be high when the equipment is in use. Operating personnel often work evening or night shifts because most large computer facilities are run 24 hours a day.

Job Requirements

In firms that have just installed a new computer system, tabulating and bookkeeping machine operators may be transferred to jobs as data entry or computer operators. More frequently, however, employers recruit experienced workers. Many high schools, public and private vocational schools, private computer schools, business schools, and community or junior colleges offer training in computer operating skills. In addition, a growing number of business firms across the country hold weekend seminars on data processing for high school students. Similarly, computer professional associations encourage student participation in professional conferences.

Employers in private industry usually require a high school education, and many prefer to hire console operators who have some community or junior college training, especially in data processing. The Federal Government requires a high school diploma, unless applicants have had specialized training or experience. Many employers test applicants to determine their aptitude for computer work, particularly their ability to reason logically.Keypunch operators and other data entry personnel often are tested for their ability to work quickly and accurately.

Beginners usually are trained on the job. The length of training needed varies -- auxiliary equipment operators can learn their jobs in a few weeks, but console operators require several months of training because they must become sufficiently familiar with the computer equipment to be able to identify the causes of equipment failures.

Keypunch and auxiliary equipment operators should be able to work under close supervision as part of a team. They also must feel comfortable working with machines and doing repetitive, organized tasks. Console operators, however, must use independent judgment, especially when working without supervision on second and third shifts.

Employment Opportunities

Employment opportunities for computer operating personnel will probably remain stable over the next few years. Although the Bureau of Labor Statistics projects a dramatic increase in the number of computer operator jobs by 1995, the actual number of new openings will be influenced by the kinds of systems businesses chose as computers are introduced for the first time or different systems are installed. Recent trends in computer markets (see "Computer Industry Profile" in **Part I** of the **Working Paper**) suggest a shift toward the increase use of microcomputers which do not necessarily require the same personnel associated with large computer systems. We assume many additional mainframe systems will also be purchased by large corporations but suggest persons seeking careers associated with large systems carefully assess trends in computer markets.

The job market for data entry operators using key-entry systems is predicted to decline in coming years based on the increased use of computer terminals and storage of data on disks and cassettes. As direct data entry techniques continue to become more efficient, the importance of punched cards as input will diminish. Despite this transition, however, there is current demand for key punch personnel to replace workers leaving these jobs. In addition, many data entry operators may transfer to terminal operator positions and word processing jobs.

WORD PROCESSOR

Unfortunately very little statistical data is available regarding word processors -- the occupation is not reported separately by the Bureau of Labor Statistics and many workers who perform word processing tasks are counted within other occupational groups, e.g. secretaries and typists.

Job Characteristics

Word processors operate various kinds of computerized typing systems equipped with memory-storage, formatting, and text-editing capabilities. An important component of all word processing systems is a video screen or linear display which shows the text as it is typed. Working from rough copy or machine transcription, word processing operators use a typewriter-like keyboard to set up the format and enter the text. Using the visual display, they monitor and proof their work, and make necessary corrections, additions or deletions prior to printing. Word processors may retrieve standardized passages stored in memory and type only the necessary changes.

Word processors work for manufacturers, government agencies, banks, insurance companies, law firms, hospitals and temporary personnel and word processing services. They may work in a large, centralized word processing center or within a department or office. Operators in word processing centers generally type more complex documents, requiring a higher level of skill and experience than those in a general office environment. Some office jobs such as **word processing secretary** combine word processing with more traditional office functions.

Job Requirements

Most employers prefer applicants with a high school diploma or the equivalent, some business courses and office experience. Minimum hiring requirements generally include typing 50 to 70 words per minute with excellent grammar, punctuation and spelling. In addition, many employers require recent word processing experience on a particular brand or type of equipment. Others may require experience in the same industry and/or familiarity with a specialized vocabulary and symbols such as engineering, legal or medical. Word processing courses may substitute for work experience for some entry-level jobs. Many businesses provide on-the-job training or send trainees to word processing classes.

Employment Opportunities

The outlook is good for experienced word processors and well-trained entry-level operators with related industry and/or equipment experience. Inexperienced applicants and those with marginal skills will face keen competition as more job seekers attain word processing skills and experience. Wages for word processors with less than one year's experience are in the $12,000 to $14,000 range. Experienced operators can earn as much as $20,000.

Advancement opportunities are limited for word processors beyond the various level associated with the occupation. Employment in an organization that employs computer professionals may provide access to higher skilled work though entry will depend on additional coursework in computers and the employer's willingness to promote from within the organization.

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Table II-A on the following page provides salary data for selected data processing occupations reported by **Datamation** (magazine) in September 1983. The survey was developed from responses of a sample of computer sites located throughout the U.S. during June 1983.

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TABLE II-A. AVERAGE ANNUAL SALARIES FOR SELECTED
DATA PROCESSING OCCUPATIONS, 1983

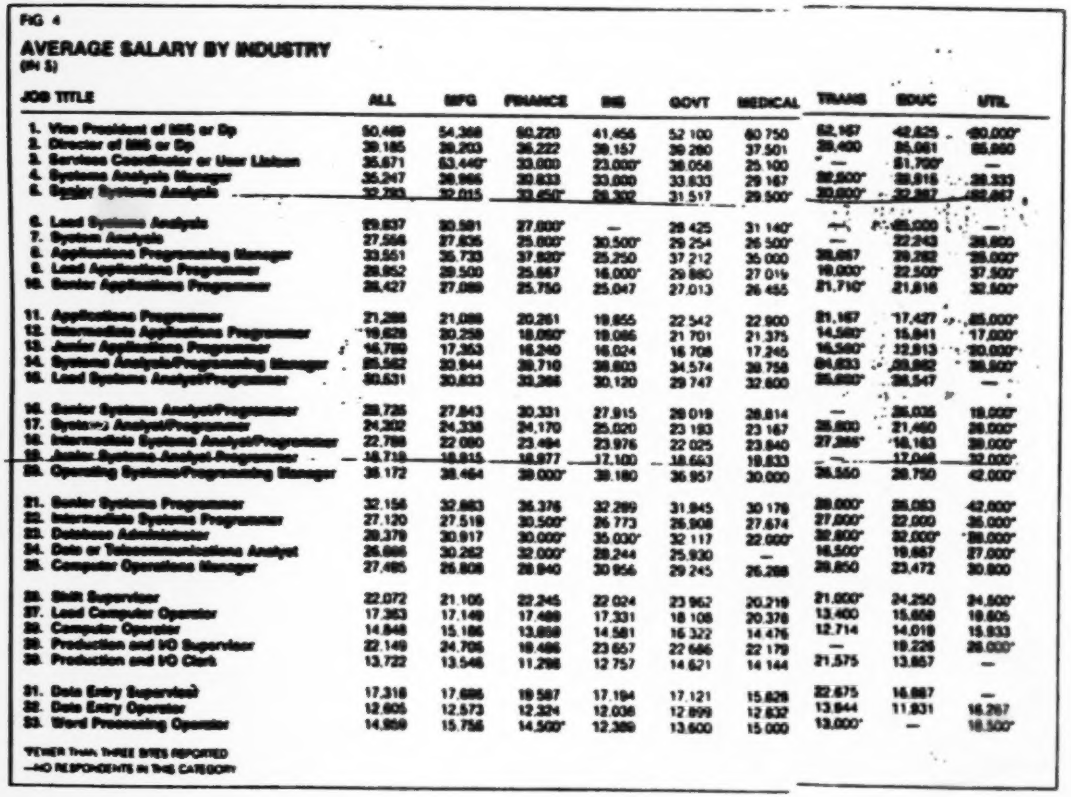


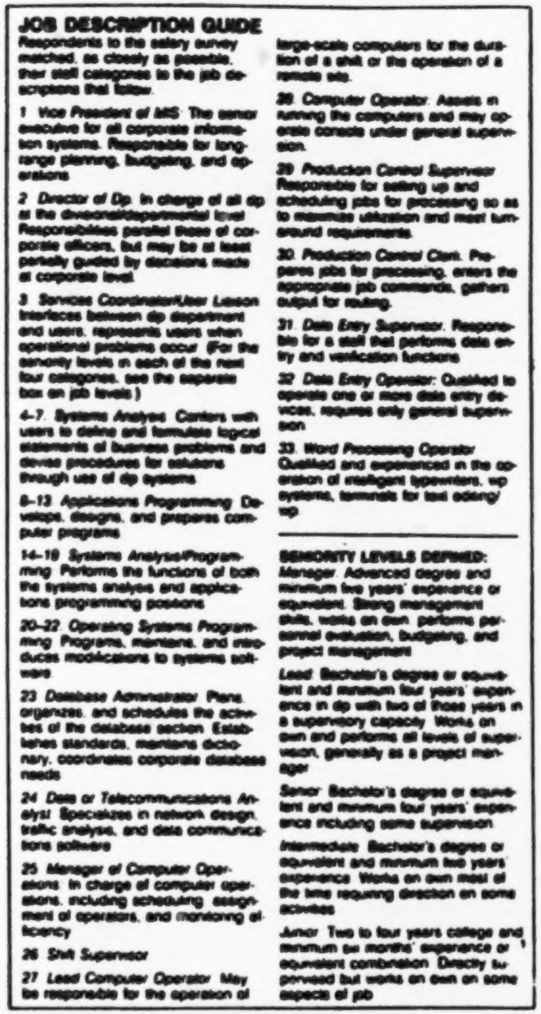
FIG 4

AVERAGE SALARY BY INDUSTRY

(IN $)

JOB TITLE	ALL	MFG	FINANCE	INS	GOVT	MEDICAL	TRANS	EDUC	UTIL
1. Vice President of MIS or Dp	50,469	54,368	60,220	41,456	52 100	60 750	52,167	42,625	60,000*
2. Director of MIS or Dp	39,185	39,203	36,222	39,157	39 280	37,501	39,400	35,061	65,650
3. Services Coordinator or User Liaison	35,671	63,440*	33,000	23,000*	38,058	25 100	—	51,700*	—
4. Systems Analysis Manager	35,247	38,966	30,833	33,000	33,830	29 167	38,500*	35,916	28,333
5. Senior Systems Analysts	32,793	32,015	33,450*	29,302	31 517	29,500*	30,000*	32,387	32,667*
6. Lead Systems Analysts	29,837	30,581	27,000*	—	28 425	31 140*	—	35,000	—
7. Systems Analysts	27,566	27,836	25,000*	30,500*	29 254	26 500*	—	22,243	28,800
8. Applications Programming Manager	33,551	35,733	37,920*	25,250	37 212	35 000	38,667	29,282	35,000*
9. Lead Applications Programmer	29,852	29,500	25,667	16,000*	29 880	27 019	19,000*	22,500*	37,500*
10. Senior Applications Programmer	26,427	27,080	25,750	25,047	27,013	26 455	21,710*	21,816	32,500*
11. Applications Programmer	21,288	21,088	20,261	19,855	22 542	22 900	21,167	17,427	25,000*
12. Intermediate Applications Programmer	19,628	20,259	18,050*	19,086	21 701	21,375	14,560*	15,841	17,000*
13. Junior Applications Programmer	16,789	17,353	16,240	16,024	16 708	17,245	16,560*	12,913	20,000*
14. Systems Analysis/Programming Manager	35,562	30,944	30,710	38,803	34,574	38 758	34,833	30,862	38,500*
15. Lead Systems Analyst/Programmer	30,531	30,833	33,286	30,120	29 747	32 600	25,600*	28,547	—
16. Senior Systems Analyst/Programmer	29,725	27,843	30,331	27,915	28 019	28,814	—	26,026	18,000*
17. Systems Analyst/Programmer	24,302	24,338	24,170	25,020	23 193	23 167	26,600	21,460	28,000*
18. Intermediate Systems Analyst/Programmer	22,788	22 000	23,494	23,976	22 025	23,840	27,286*	18,163	30,000*
19. Junior Systems Analyst/Programmer	18,719	18,815	18,877	17,100	18,663	19,833	—	17,048	32,000*
20. Operating Systems/Programming Manager	36,172	38,464	39,000*	38,180	36,957	30,000	36,560	28,750	42,000*
21. Senior Systems Programmer	32,156	32,883	36,376	32,289	31,845	30 178	30,000*	26,083	42,000*
22. Intermediate Systems Programmer	27,120	27,519	30,500*	26 773	26,908	27,674	27,000*	22,000	35,000*
23. Database Administrator	29,379	30,917	30,000*	35,000*	32 117	22,000*	32,800*	32,000*	38,000*
24. Data or Telecommunications Analyst	26,886	30,262	32,000*	28,244	25,930	—	16,500*	19,867	27,000*
25. Computer Operations Manager	27,485	26,808	28 840	30 956	29 245	26,288	28,850	23,472	30,800
26. Shift Supervisor	22,072	21,105	22,245	22 024	23 962	20,219	21,000*	24,250	24,500*
27. Lead Computer Operator	17,383	17,149	17,489	17,331	18 108	20,378	13,400	15,669	18,605
28. Computer Operator	14,848	15,186	13,859	14 581	16 322	14 476	12,714	14,018	15,833
29. Production and I/O Supervisor	22,149	24,705	18,486	23 657	22 686	22 179	—	19,226	26,000*
30. Production and I/O Clerk	13,722	13,546	11,298	12 757	14 621	14 144	21,575	13,857	—
31. Data Entry Supervisor	17,318	17,686	18 587	17,194	17,121	15,628	22,675	16,887	—
32. Data Entry Operator	12,605	12,573	12,324	12,036	12 899	12 832	13,844	11,931	16,267
33. Word Processing Operator	14,858	15,756	14,500*	12,389	13,600	15 000	13,000*	—	18,500*

*FEWER THAN THREE SITES REPORTED
—NO RESPONDENTS IN THIS CATEGORY



JOB DESCRIPTION GUIDE

Respondents to the salary survey matched, as closely as possible, their staff categories to the job descriptions that follow.

1. *Vice President of MIS*: The senior executive for all corporate information systems. Responsible for long-range planning, budgeting, and operations.

2. *Director of Dp*: In charge of all dp at the divisional/departmental level. Responsibilities parallel those of corporate officers, but may be at least partially guided by decisions made at corporate level.

3. *Services Coordinator/User Liaison*: Interfaces between dp department and users; represents users when operational problems occur. (For the seniority levels in each of the next four categories, see the separate box on job levels.)

4–7. *Systems Analysis*: Confers with users to define and formulate logical statements of business problems and devise procedures for solutions through use of dp systems.

8–13. *Applications Programming*: Develops, designs, and prepares computer programs.

14–19. *Systems Analysis/Programming*: Performs the functions of both the systems analysis and applications programming positions.

20–22. *Operating Systems Programming*: Programs, maintains, and introduces modifications to systems software.

23. *Database Administrator*: Plans, organizes, and schedules the activities of the database section. Establishes standards, maintains dictionary, coordinates corporate database needs.

24. *Data or Telecommunications Analyst*: Specializes in network design, traffic analysis, and data communications software.

25. *Manager of Computer Operations*: In charge of computer operations, including scheduling, assignment of operators, and monitoring efficiency.

26. *Shift Supervisor*.

27. *Lead Computer Operator*: May be responsible for the operation of large-scale computers for the duration of a shift or the operation of a remote site.

28. *Computer Operator*: Assists in running the computers and may operate console under general supervision.

29. *Production Control Supervisor*: Responsible for setting up and scheduling jobs for processing so as to maximize utilization and meet turnaround requirements.

30. *Production Control Clerk*: Prepares jobs for processing, enters the appropriate job commands, gathers output for routing.

31. *Data Entry Supervisor*: Responsible for a staff that performs data entry and verification functions.

32. *Data Entry Operator*: Qualified to operate one or more data entry devices; requires only general supervision.

33. *Word Processing Operator*: Qualified and experienced in the operation of intelligent typewriters, wp systems, terminals for text editing/wp.

SENIORITY LEVELS DEFINED:

Manager: Advanced degree and minimum five years' experience or equivalent. Strong management skills, works on own, performs personnel evaluation, budgeting, and project management.

Lead: Bachelor's degree or equivalent and minimum four years' experience in dp with two of those years in a supervisory capacity. Works on own and performs all levels of supervision, generally as a project manager.

Senior: Bachelor's degree or equivalent and minimum four years' experience including some supervision.

Intermediate: Bachelor's degree or equivalent and minimum two years' experience. Works on own most of the time requiring direction on some activities.

Junior: Two to four years college and minimum six months' experience or equivalent combination. Directly supervised but works on own on some aspects of job.

Source: Reprinted from DATAMATION (September 1983).

Occupation: **COMPUTER SERVICE TECHNICIAN**

Employment, 1982 (000s)	55	
Women, % of total	10%	
Men, % of total	90%	
Median weekly earnings, 1982	430	
Women (% of men's wages)	400	(93%)
Men	433	
Employment, 1995 (000s)	108	
% change, 1982-95	97%	

Source: U.S. Department of Labor,
Bureau of Labor Statistics

Job Characteristics

A computer system consists of a central processing unit and additional equipment such as remote terminals and high-speed printers. Keeping this intricate equipment in good working order is the job of computer service technician. At regular intervals, computer service technicians (often called field engineers or customer engineers) service machines or systems to keep them operating efficiently. They routinely adjust, oil, and clean mechanical and electromechanical parts. They also check electronic equipment for loose connections and defective components or circuits.

When computer equipment breaks down, technicians must quickly find the cause of the failure and make repairs. Determining where in the system the malfunction has occurred is the most difficult part of the technician's job, and requires a logical, analytical mind as well as technical knowledge. As computer systems have grown more complex and networks of minicomputers have developed, the potential for malfunctions also has grown.

Breakdowns can occur in the central processing unit itself, in one of the peripheral machines, in the remote mini's that are connected to the central unit, or in the cables or datacommunications hookups that connect these machines. To locate the cause of electronic failures, technicians use several kinds of tools, including voltmeters, ohmmeters, and oscilloscopes. They run special diagnostic programs that help pinpoint certain malfunctions. Although it may take several hours to locate a problem, fixing the equipment may take just a few minutes. To replace a faulty circuit board, solder a broken connection, or repair a mechanical part, technicians use a variety of handtools, including needle-nosed pliers, wirestrippers, and soldering equipment. The employer supplies tools and test equipment, but technicians are responsible for keeping them in good working order.

Computer technicians often help install new equipment. They lay cables, hook up electrical connections between machines, thoroughly test the new equipment, and correct any problems before the customer uses the machine. Some technicians specialize in maintaining a particular computer model or system, or in doing a certain type of repair. For example, some technicians are experts in correcting problems caused by errors in the computer's internal programming.

Besides knowing how to use specialized tools and test equipment, computer technicians must be familiar with technical and repair manuals for each piece of equipment. They also must keep up with the technical information and revise maintenance procedures issued periodically by computer manufactures. Technicians keep a record of preventive maintenance and repairs on each machine they service. In addition, they fill out time and expense reports, keep parts inventories, and order parts.

Although technicians spend most of their time working on machines, they work with people also. They listen to customers' complaints, answer questions, and sometimes offer technical advice on ways to keep equipment in good condition. Experienced technicians often help train new technicians and sometimes have limited supervisory duties.

Computer installations generally run around the clock and working time lost because of a breakdown can be very expensive. For this reason, technicians must be available to make emergency repairs at any time, day or night. Although the normal workweek is 40 hours, overtime is commonplace. The method of assigning overtime varies by employer. Some technicians are on call 24 hours a day. Others work rotating shifts--days one week, nights the next. For most technicians, travel is local; they usually are not away from home overnight. Employers pay for travel, including reimbursement for job-related uses of the technician's car, as well as work-related education expenses.

Although some bending and lifting are necessary, the job is not strenuous. Work hazards are limited mainly to minor burns and electric shock, but these can be avoided if safety practices are followed.

Job Requirements

Most employers require applicants for technician trainee jobs to have 1 to 2 years' post-high school training in basic electronics or electrical engineering. This training may be from a public or private vocational school, a college, or a junior college. A high school student interested in becoming a computer service technician should take courses in mathematics and physics. High school courses in electronics and computer programming also are helpful.

Hobbies that involve electronics, such as operating ham radios or building stereo equipment, also provide valuable experience.

Besides technical training, applicants for trainee jobs must have good vision and normal color perception to work with small parts and color-coded wiring. Normal hearing is needed since some breakdowns are diagnosed by sound. Because technicians usually handle jobs alone, they must have the initiative to work without close supervision. In some companies, applicants must pass a physical examination. A security clearance may be required in cases where technicians regularly service machines located in restricted buildings, such as Federal Government installations engaged in classified activities.

Trainees usually attend company training programs for 3 to 6 months to learn elementary computer theory, computer math, and circuitry theory and to further their study of electronics. Classroom work is accompanied by practical training in operating computer equipment, doing basic maintenance, and using test equipment to locate malfunctions.

In addition to formal instruction, trainees must complete 6 months to 2 years of on-the-job training. At first, they work closely with experienced technicians, learning to maintain care readers, printers, and other machines that are relatively simple, but that have the basic mechanical and electronic features of a large computer system. As trainees gain experience, they work on more complex equipment.

Because manufacturers continually redesign equipment and develop new use for computers, experienced technicians frequently must attend training sessions to keep up with these changes and to broaden their technical skills. Many technicians take advanced training to specialize in a particular computer system or type of repair. Instruction also may include programming, systems analysis, and other subjects that improve the technician's general knowledge of the computer field.

Experienced technicians with advanced training may become specialists or "trouble-shooters" who help technicians throughout their territory diagnose difficult problems. They also may work with engineers in designing equipment and developing maintenance procedures. Technicians with leadership ability may become supervisors or service managers.

Most computer equipment operates on the same basic principles, but machines built by different companies may be unique in design and construction. For this reason, technicians may find it difficult to transfer between companies that maintain different brands of equipment. However, because of the pressing need for experienced technicians, many opportunities exist for well-qualified workers to transfer to other firms that handle the same type of computer hardware. Training and experience in computer maintenance may also help qualify a technician for a job in equipment sales, programming, or management.

Employment Opportunities

Computer service technicians have been predicted to be the fastest growing occupational group through 1995 according to the Bureau of Labor Statistics. This forecast is based on the increase in the number of computers that will occur over the next decade combined with the decentralization of computers.

Most computer service technicians are employed by manufacturers of computer equipment or by firms that provide maintenance services on a fee basis. A small number are employed by organizations that operate large computer installations. Most of these technicians work out of regional offices located in large urban areas where computer equipment is concentrated.

The very strong demand for computer technicians is related to the growing number of computers in operation and the geographic distribution of these computers. Continued reductions in the size of computer hardware will bring the computer within reach of a rapibly increasing number of small organizations. As more and more of these small systems are installed, the amount of time technicians must spend traveling between clients will increase.

Employment of computer service technicians is much less likely to be affected by downturns in business activity that is the case in other fields. Because computer operations are rarely curtailed during economic slumps, employment or computer service technicians should remain relatively stable. Computer service technicians currently earn on the average around $20,000 per year with the top ten percent commanding salaries in excess of $30,000.

Although no statistical data is available, another growing, related occupation is the computer repairer. These individuals work for businesses such as retailers of computers, independent repair firms and others that service small computers. Workers in other occupations who repair and maintain the circuits and mechanical parts of electronic equipment include appliance repairers, automotive technicians, business machine repairers, instrument repairers, radio repairers, radar mechanics and television service technicians.

SECTION III. RELATED OCCUPATIONS

This section details occupations that are complimentary to high technology and user industries as well as being associated with other employment sectors. The general categories included are technical sales and marketing occupations, mathematics specialties, technical writing and mechanic, repair and installation jobs.

TECHNICAL SALES AND MARKETING -- MICROELECTRONICS

The field of technical sales and marketing is growing in importance in microelectronics manufacturing and computer service industries as well as other sectors of the economy. The number of technical sales positions (based on all industries) is expected to increase to 1.7 million by 1995 or 30% over 1982 levels. Although the number of technical representatives associated with microelectronic and data processing sales is unknown and probably represents a small portion of all technical sales workers, indicators suggest a positive outlook for persons entering these occupations.

Marketing

Marketing personnel are involved in the planning, organizing, and coordinating of technical programs to insure accomplishment of a task order, financial and budgetary goals, development and production schedules and objectives. They often coordinate program planning with customers to insure identification of appropriate schedules, cost and related considerations. Marketing specialists perform liaison functions with customers, negotiate contracts and coordinate details within the company. For marketers of manufactured products this may involve working with design, engineering, production, finance, purchasing and other departments.

Requirements for marketing positions generally include advanced knowledge of company product lines/services and potential applications as well as technical understanding of product and customer requirements. In addition, marketing personnel need experience in management techniques and controls, marketing, and contract administration. Most workers in this profession have at least a bachelor's degree in engineering, business, computer science or a related field and several years experience in technical program management. Although salary data is not readily available, annual wages are likely to exceed $30,000.

Sales

Many high tech companies have inside and outside field sales representatives. Inside personnel generate sales of products/services through direct telephone contact with customers. Entry-level personnel handle incoming calls by providing product information (pricing, delivery and availability), making pricing decisions, initiating orders for processing and checking customer credit status. They also maintain customer records and coordinate with field sales personnel. Experienced inside sales representatives are responsible for generating sales (via telephone) with major customers and providing professional sales support for the field sales force.

Employers seek inside sales representatives with two years of college or equivalent experience and with 2 to 5 years of related work experience in areas such as purchasing, sales, marketing, order processing, and related functions. Applicants must also know the product line and its market as well as understand marketing trends, financial analysis of sales data, and sales profitability.

Outside or field representatives are generally more experienced in sales and product applications. For example, computer salespersons may work with a potential customer for months before selling a system or a piece of equipment. Frequently knowledge of the customer's business (industry) and organizational structure are necessary requirements for handling this kind of sales work. Most computer sales workers specialize in business or engineering/scientific applications.

Employers seem to prefer applicants for field sales in computers with a college degree -- though knowledge of computers and data processing is helpful, it's not always required -- or workers with experience in sales in an allied technical or management fields. Most computer manufacturers provide intensive sales training to beginning sales personnel, often involving several weeks or months of paid training. This is followed by on-the-job training under supervision of a senior salesperson.

Earnings for computer field personnel are often based on salary plus commission for each sale. Entry-level salaries are often in the $18,000 range and can grow to very high levels for experienced, successful sales representatives. Sales representatives for data processing services earn salaries in the $15,000 to $20,000 range on the average.

Although we've distinguished marketing from sales jobs, positions in many business combine various functions of both. Similarly inside and outside sales activities maybe combined within one position. There is also evidence that some businesses are increasing inside sales forces to reduce the costs associated with field sales along with a transfer of selected sales responsibilites to field engineers or service technicians.

MATHEMATICS SPECIALISTS

Mathematics specialists include mathematicians, statisticians, actuaries and other related occupations. Employment for this group is expected to increase from 48,000 in 1982 to 62,000 by 1995 or by 29%. The majority (75%) of mathematicians worked for colleges and universities in 1980 -- most were employed as teachers though some worked mainly in research and development programs. The remainder (about 25%) worked primarily for high-tech industries. During that year the majority of statisticians worked in private industry -- primarily in manufacturing, finance and insurance -- while others were concentrated in government agencies.

MATHEMATICIANS

Mathematicians work in one of the oldest and most basic sciences. Mathematicians today are engaged in a wide variety of activities, ranging from the creation of new theories to the translation of scientific and managerial problems into mathematical terms. Mathematical work falls into two broad classes: theoretical (pure) mathematics; and applied mathematics. However, these classes are not sharply defined and often overlap.

Theoretical mathematicians advance mathematical science by developing new principles and new relationships between existing principles of mathematics. Although they seek to increase basic knowledge without necessarily considering its practical use, this pure and abstract knowledge has been instrumental in producing many scientific and engineering achievements.

Applied mathematicians use mathematics to develop theories, techniques, and approaches to solve practical problems in business, government, engineering, and the natural and social sciences. Their work ranges from analysis of the mathematical aspects of launching communications satellites to studies of the effects of new drugs on disease. Much work in applied mathematics, however, is carried on by persons other than mathematicians. In fact, the number of workers who depend upon mathematical expertise is many times greater than the number actually designated as mathematicians.

Job Requirements

An advanced degree is the basic requirement for beginning teaching jobs, as well as for most research positions. In most four-year colleges and universities, the Ph. D. degree is necessary for full faculty status. A master's degree is adequate preparation for teaching jobs in most two-year colleges and technical institutes.

Although the bachelor's degree may be adequate preparation for some jobs in private industry and government, employers usually require an advanced degree. Those bachelor's degree holders who find jobs as mathematicians usually assist senior mathematicians by performing computations and solving less advanced problems in applied mathematics. However, advancement often depends on achieving an advanced degree. Other bachelor's degree holders work as research or teaching assistants in colleges and universities while studying for an advanced degree. The majority of bachelor's degree holders work in related fields such as computer science.

The bachelor's degree in mathematics is offered by most colleges and universities. Mathematics courses usually required for a degree are analytical geometry, calculus, differential equations, probability theory and statistics, mathematical analysis, and modern algebra. Many colleges and universities urge or even require students majoring in mathematics to take several courses in a field that uses or is closely related to mathematics, such as computer science, operations research, a physical science, or economics. A prospective college mathematics student should take as many mathematics courses as possible while in high school.

More than 400 colleges and universities offer the master's degree in mathematics; about 150 also offer the Ph. D. In graduate school, students conduct research and take advanced courses, usually in a specific field of mathematics such as algebra, mathematical analysis, or geometry. For work in applied mathematics, training in the field in which the mathematics will be used is very important. Fields in which applied mathematics is used extensively include physics, engineering, and operations research; of increasing importance are business and industrial management, economics, statistics, chemistry and life sciences, and the behavioral sciences.

Mathematicians should have a good knowledge of computer programming since most complex mathematical computation is done by computer. Mathematicians need good reasoning ability, persistence, and the ability to apply basic principles to new types of problems. They must be able to communicate well since they often need to discuss the problem to be solved with nonmathematicians.

Employment Outlook

Employment of mathematicians is expected to increase more slowly than the average for all occupations through the 1980's because the majority of mathematicians work in colleges and universities, where little employment growth is expected. Those with Ph.D. degrees in mathematics should have favorable employment opportunities. However, most job openings for Ph.D.'s will either be in industry or in college faculty positions at the undergraduate level. There will be competition for jobs involving theoretical research or for research oriented university faculty positions.

Holders of Ph.D. degrees in applied mathematics should have better employment prospects than those whose interest and training are confined to the theoretical aspects of mathematics. Although some opportunities may be available to theoretical mathematicians in nonacademic areas, most nonacademic employers will seek applied mathematicians who can solve practical problems. Private industry and government agencies will need applied mathematicians for work in operations research, numerical analysis, computer systems programming, applied mathematical physics, market research, and commercial surveys, and as consultants in industrial laboratories.

Those with only a bachelor's or master's degree in mathematics may have difficulty finding a job as a mathematician because most jobs in teaching or research require a Ph.D., although there will be some openings in applied areas and in two-year college teaching. However, a mathematics degree makes one well qualified to enter related occupations such as statistician, actuary, computer programmer, systems analyst, economist, engineer, and physical or life scientist. Employment opportunities in these fields will probably be best for those who combine a major in mathematics with a minor in one of these subjects. Graduates with state teaching certificates may also find openings as high school math teachers, given a renewed emphasis by many states to increase math requirements and find qualified teachers, there may be good opportunities in certain parts of the country.

Starting salaries for mathematicians with a bachelor's degree are about $18,000, with a master's degree, $20,000 and with a Ph.D., $27,000.

STATISTICIANS

Job Characteristics

Statisticians devise, carry out, and interpret the numerical results of surveys and experiments. In doing so, they apply their knowledge of statistical methods to a particular subject area, such as economics, human behavior, natural science, or engineering. They may use statistical techniques to predict population growth or economic conditions, develop quality control tests for manufactured products, or help business managers and government officials make decisions and evaluate the results of new programs.

Often statisticians are able to obtain accurate information about a group of people or things by surveying a small portion, called a sample, rather than the whole group. Statisticians decide where and how to get the data, determine the type and size of the sample group, and develop the survey questionnaire or reporting form. They also prepare instructions for workers who will tabulate the returns.

Since statistics are used in so many areas, it sometimes is difficult to distinguish statisticians from specialists in other fields who use statistics. For example, a statistician working with data on economic conditions may have the title of economist.

Job Requirements

A bachelor's degree with a major in statistics or mathematics is the minimum educational requirement for many beginning jobs in statistics. For other entry level statistical jobs, however, a bachelor's degree with a major in an applied field such as economics or natural science and a minor in statistics is preferable. A graduate degree in mathematics or statistics is essential for college and university teaching.

Over 200 colleges and universities offered statistics as a concentration for a bachelor's degree in 1980. Many schools also offer either a degree in mathematics or a sufficient number of courses in statistics to qualify graduates for beginning positions. Required subjects for statistics majors include mathematics through differential and integral calculus, statistical methods, and probability theory. Courses in computer uses and techniques, if not required, are highly recommended. For quality-control positions, training in engineering or physical or biological science is desirable. For many market research, business analysis, and forecasting jobs, courses in economics and business administration are helpful.

Many colleges and universities also offered graduate degrees in statistics in 1980, and many other schools offered one or two graduate level statistics courses. Acceptance into graduate programs does not require an undergraduate degree in statistics although a good mathematics background is essential.

Beginning statisticians who have only the bachelor's degree often spend much of their time performing routine work under the supervision of an experienced statistician. Through experience, they may advance to positions of greater technical and supervisory responsibility. However, opportunities for promotion are best for those with advanced degrees.

Job Opportunities

Employment opportunities for persons who combine training in statistics with knowledge of a field of application are expected to be favorable through the 1980's Private industry will require increasing numbers of statisticians for quality control in manufacturing. Statisticians with knowledge of engineering and the physicial sciences will find jobs working with scientists and engineers in research and development. Business firms will rely more heavily than in the past on statisticians to forecast sales, analyze business conditions, modernize accounting procedures, and help solve management problems.

Many fields such as law and history have recognized the usefulness of statistics, and statistical techniques are being used increasingly to determine such things as the effects of pollution and toxic substances. As the use of statistics expands into new areas, more statisticians will be needed.

Federal, state, and local government agencies will need statisticians for existing and new programs in fields such as transportation, social security, health, and education. The broader use of statistical methods is also likely to result in a need for more teachers of statistics in colleges and universities.

Beginning salaries for statisticians range from $13,000 to $25,000 depending upon their level of education. Workers in the following occupations use statistics to such an extent their job is often similar to that of a statistician: marketing research workers, urban and regional planners, engineers, environmental scientists, life scientists, physical scientists, and social scientists. Others who work with numbers are actuaries, mathematicians, financial analysts, computer programmers, and systems analysts.

[See Appendix B for a list of occupations that utilize mathematical skills.]

TECHNICAL WRITERS

Technical writing is a field that is expected to grow over the coming years as more and more electronic equipment is introduced into the market place. Although the recent population of these professionals is small -- about 25,000 workers were in employed as technical writers in 1980 -- growth in this occupation is expected to increase faster than for most other jobs.

Technical writers in high tech manufacturing often prepare operation and maintenance manuals and technical publications by gathering technical information, preparing written texts and coordinating the layout and manual organization. In order to accomplish these tasks, technical writers research available engineering information such as drawings, design reports, equipment and test specifications and by interviewing engineers and other technical personnel.

The following paragraphs provide additional detail on this occupation for workers in high tech and other employment sectors as provided in the Occupational Outlook Handbook.

Job Characteristics

Technical writers put scientific and technical information into readily understandable language. They research, write, and edit technical materials and also may produce publications, sales or audiovisual materials. Technical writers use their knowledge of a technical subject area along with their command of language and versatility of style to convey information to people who need it-- scientists, engineers, technicians, mechanics and repairers, managers, sales representatives, and the general public. In addition to clarifying technical information, technical writers often use their writing skills in marketing, advertising, and public relations work.

Some organizations use job titles other than "technical writer". Depending on the employers, people in technical writing jobs may be called staff writers, publications engineers, communications specialists, industrial writers, medical writers, communicators, or instructional materials developers.

Technical writers prepare manuals, catalogs, parts lists, and instructional materials used by sales representatives to sell machinery or scientific equipment and by technicians to install, maintain , and service it. Instructional aids assist people who operate complex equipment--for example, technicians who monitor sophisticated diagnostic equipment in a hospital's coronary care unit. Sometimes technical writers write scripts for training films, or prepare instructional materials for self-teaching cassettes, filmstrips, or kits. Technical writers often are part of a team, working closely with scientists, engineers, accountants, and others.

Many technical writers prepare reports on research. They communicate research developments to other scientists, engineers, and technicians to help prevent duplication of effort and to speed scientific and technical progress. Technical writers also prepare detailed reports for government regulatory agencies. Technical writers also may prepare proposals. A team of technical writers usually writes the final proposal using technical information prepared by scientists and engineers and cost estimates from managers and accountants.

Technical writers may also write specifications; prepare speeches and news releases; edit and write technical books and journals; prepare articles for popular magazines; develop advertising copy, promotional brochures, and texts for exhibits and display; and handle technical documentation. They also sometimes prepare annual corporate reports to stockholders.

Technical writers starting an assignment learn as much as they can about the subject within the time permitted. They study reports, blueprints, sketches, drawings, parts lists, specifications, mockups, and product samples to become familiar with product technologies and production methods. They also read technical journals; consult with engineers, scientists, and technicians who may have worked on a project; and examine the equipment. Technical writers usually coordinate the preparation by technical illustrators, drafters, or photographers of tables, charts, illustrations, and other artwork for the document.

Established technical writers may work on a freelance basis or operate their own agencies or consulting firms. Freelance technical writers sell their work to publishers, manufacturing firms, and advertising agencies. They usually are hired to complete specific assignments such as writing about new products or techniques.

Job Requirements

There are no rigid requirements for entry into the field. People having a variety of backgrounds find jobs as technical writers. Employers seek people whose education, work experience, and personal pursuits indicate that they possess both writing skills and appropriate scientific or technical knowledge. Knowledge of graphics and other aspects of publication production may be helpful in getting a job. An understanding of communications technology and computers is increasingly important.

A college degree is helpful, and many employers require it. Many employers prefer candidates with a degree in science or engineering, plus a minor or an advanced degree in English, journalism, or technical communications. Others emphasize writing ability. They look for candidates with degrees in journalism, English, or the liberal arts and courses or practical experience in a technical field -- computer science or biochemistry, for example.

Many employers consider only seasoned, experienced writers in filling vacancies. Some firms hire recent college graduates for writer trainee positions. People with backgrounds in science or engineering or with degrees in technical writing are often preferred. However, a degree in almost any field may be acceptable if the candidate has technical and communications skills. Most technical writers do not enter the occupation directly from college. The majority work initially in other jobs, usually as technicians, scientists, or engineers. Some begin as research assistants,. editorial assistants, or trainees in a company's technical information or advertising departments. In time, these people may assume writing duties and develop technical communication skills.

In 1980, about 10 colleges and universities offered bachelor's degree programs in technical communication, science or medical writing, science information, or technical journalism; a few had master's degree programs. Several community and junior colleges offered associate degree programs.

Programs in technical writing are interdisciplinary. Most are based in communications, journalism, or language and literature departments, and have close cooperation with the mathematics, engineering, and science departments. At most schools, about 30 percent of the courses are in communications. Courses include communication theory, writing and editing, layout and design, and graphics. From 25 to 40 percent are in science or technology, and the remainder are in the social sciences and humanities, foreign languages or electives. At many schools, internships in industry or government give technical writing students first-hand job experience.

Hundreds of other colleges and universities offer technical writing or related courses which are available to science and engineering students. Related courses in copy editing, publication design, graphic arts, typography, technical advertising, industrial communications, and proposal writing, for example, are also desirable because they broaden the publications background of writers, making them more valuable to prospective employers. Many engineering schools offer English courses to sharpen writing skills, and several have extensive course offerings in technical writing. Several schools of journalism offer courses in medical journalism. Numerous special institutes, seminars, and workshops are available to bring experienced technical writers up to date. These are sponsored by colleges and universities, technical communication consultants, or organizations that specialize in employee training and development.

Beginners often do library research for experienced technical writers and prepare drafts of reports. As they demonstrate their ability to write and organize information, they are given more responsibility. Experienced writers in companies with large technical writing staffs become technical editors or shift to administrative positions in the publications or technical information departments. The top job in technical writing is publications manager, in charge of producing all technical documents. The manager supervises not only the technical writers and editors, but also the staff responsible for illustrations, photography, photography, reproduction, and distribution.

After gaining experience and contacts, some technical writers freelance or form their own firms. Some handle industrial publicity and technical advertising for corporate clients. Other technial communications firms write and produce catalogs, manuals, and brochures for the promotion of a new product. Some experienced technical writers conduct writing seminars in industry and government, and others teach at colleges or universities in addition to their regular jobs. Some technical writers freelance by becoming specialists in particular scientific or technical subjects. They sometimes prepare syndicated newspaper columns or articles for popular magazines.

Employment Outlook

Demand for technical writers is expected to increase because of the continuing expansion of scientific and technical information and the continued need to communicate it to researchers, corporate managers, sales representatives, and technicians. With the increasing complexity of industrial and scientific equipment, more users will depend on the technical writer's ability to prepare precise but simple explanations and instructions. However, the tendency for many scientists and engineers to do their own writing may limit growth of technical writing jobs.

An estimated 25,000 technical writers and editors were employed in 1980. Many work for large firms in the electronics, aircraft and parts, chemical, pharmaceutical, and computer manufacturing industries. Firms in the energy, communications, and computer software fields also employ many technical writers, as do research laboratories. Many technical writers work directly for business and trade publications; professional journals in engineering, medicine, physics, chemistry, and other sciences; and with publishers of scientific and technical books.

The rapidly growing information industry provides a major area of employment for technical writers. Technical information centers run by major industrial firms and research laboratories and commercial firms that provide clients with access to computerized data bases employ technical information specialists to collect, process, and manage a vast amount of information. Technical writers are particularly well suited for these jobs because of their combination of technical and communications skills.

Expenditures for research and development (R&D) will continue to have a significant effect on job opportunities for technical writers. Their employment, like that of scientists and engineers, is linked to spending levels for research and for product development on areas such as national defense, energy development and conversion, medicine, environmental health and safety, and communications technology. Through the 1980's R&D expenditures are expected to increase more rapidly than during the 1970's. If actual expenditures differ significantly from the levels anticipated, the outlook for technical writers would be altered.

Employment opportunities will be best for experienced technical writers and for beginners who have both demonstrated writing ability and a scientific or technical background. Graduates of technical writing programs should be in particular demand. Competition for technical writing jobs will probably continue to be less than for writing and editing jobs in general.

According to the Amercian Management Association starting salaries for technical writers averaged $55,200 in 1980 with experienced writers earning from $17,000 to $25,000. Technical editors earned from $20,000 to over $30,000 during that year. Earnings appear to be higher on the East Coast and in California.

MECHANICS, REPAIRERS AND INSTALLERS

The demand for craft workers in these general occupations is expected to grow based on the increased use of machinery and equipment in a technologically sophisticated economy and the introduction of new equipment and products. Skilled mechanics, repairers and/or installers are needed to work on industrial machinery, transportation equipment, communications equipment, appliances and a variety of other industrial, commercial and household mechanisms. During 1982 nearly 4 million workers were classified under this broad job category and by 1995 it has been estimated that employment will grow to over 5 million representing a 30% increase.

The largest group of workers employed as mechanics, repairers and installers (844,000 in 1982) were classified as automotive mechanics followed by maintenance (general utility) repairers (694,000), diesel mechanics (173,000), and industrial machinery repairers (330,000), and air conditioning, refrigeration and heating mechanics (168,000). All of these groups are expected to increase over the next several years. In addition, relatively smaller (yet sizeable in terms of actual employment) occupational groups more closely affiliated with high tech industries and products are also slated for growth. Among these are telephone line installers (127,000 in 1982), engineering equipment mechanics (83,000), radio and television service technicians (80,000), office machine repairers (56,000), computer service technicians (55,000) and cable (telephone) splicers (48,000).

Job Characteristics

The primary tasks associated with the maintenance and repair of equipment and machinery are solving, correcting and preventing mechanical problems. Diagnostic work is often difficult -- mechanics and repairers must have thorough knowledge of the equipment and its functions and be able to dissassemble, repair, and reassemble the equipment. In order to diagnose a problem the worker may have to perform tests with specialized instruments or equipment and use repair books and technical manuals as well as use her own ingenuity and knowledge of the equipment. Repair work generally involves the use of common hand and power tools such as screwdrivers, pliers, and electric drills in addition to specialty tools of specific trades. The installation of equipment and machinery requires comparable mechanical skills.

Job Requirements

Training for most mechanic and repairer occupations requires both classroom instruction in machine operation and practice in repair work. Mechanics obtain this training through high school and postsecondary programs or on-the-job training. Employers prefer high school graduates who have had course work in shop math, blueprint reading, drafting, metal working and electronics that forms a base of mechanical knowledge and skills. Training in specific areas is available through high schools, vocational institutions, community colleges, and other organizations providing skills training. Although completion of such training does not insure employment, employers increasingly prefer applicants with some training or experience.

Entry-level mechanic and repair personnel usually receive on-the-job training from their employers. This preparation may involve classroom instruction and practice work with demonstration equipment but more frequently consists of supervision by an experienced worker. To keep pace with technological changes and improvements, mechanics and repairers must continue training throughout their careers by studying repair books and technical manuals that accompany new equipment.

The sophisticated technology that marks our society revolves largely around electrical and electronic equipment. Electrical and electronic equipment repairers install, maintain, and repair this equipment. Many of them deal with the highly complex communications and data transmission equipment that, within a very short time, has brought computers into everyday use in factories, hospitals, schools, stores, homes, and many other places.

Mechanical aptitude and a knowledge of electrical theory are essential in these occupations. For many of them, some knowledge of advanced electronic theory and skill in the use of electronic testing equipment are also necessary. At the entry level, repairers may need only a high school diploma. They acquire specific job skills through on-the-job training, a formal apprenticeship, or an employer's training program. For many of these jobs, however, employers require formal training in electronics, which may be obtained in vocational-technical institutes, community colleges, or private trade schools. Continuing education is important in this rapidly changing field, and many electronic equipment repairers periodically attend company-sponsored training sessions to learn about new technological advances and to sharpen their repair skills.

Employment Outlook

In general the outlook for mechanics, repairers and installers is positive and most promising for those occupations that are associated with electronic and electromechical machinery and equipment. It is important that workers entering these trades develop strong basic skills since the potential for transferability from one type of job to another is directly proportional to the mastery and breadth of mechanical, electrical and electronic skills and experience. **Table III-A** provides projected employment data for selected occupations within the group.

It should be noted at the present time that few women are represented among these occupations. During 1982 less than five percent of all employed mechanics and repairers were women. Furthermore, women accounted for no more than 10% of all workers in any of the specialty areas (e.g. women represented only 8% of all data processing machine repairers). It appears, however, that the earnings ratios for the few women in these fields were much healthier than the average. For example, women in the broad category of mechanics and repairers had medican weekly earnings of $318, or 92% of their male counterparts' wages. At a more refined level, women who worked as data processing machine repairers earned median incomes of $400 (92% of men's eages); as office machine mechanics they earned $332 (88% of men's earnings); as telephone line installers and repairers $381 (96% of men's wages); and radio and teversion repairers $241 (70% of men's wages).

In response to the above, it is clear that women should be encouraged to prepare for and enter the many "nontraditional" occupations included in the repair, maintenance and installation job categories that are projected to grow over the next decade.

TABLE III-A. SELECTED EMPLOYMENT PROJECTIONS FOR MECHANICS, REPAIRERS AND INSTALLERS -- ALL INDUSTRIES

	Employment (000s)		Percent
Occupation	1982	1995*	Change
Mechanics, repairers and installers	3,936	5,107	30 %
Air conditioning, refrigeration and heating mechanics	168	223	33
Aircraft mechanics	108	128	19
Automotive mechanics	844	1,168	38
Cable splicers	48	60	25
Computer service technicians	55	108	97
Diesel mechanics	173	222	28
Engineering equipment mechanics	83	94	13
Industrial machinery repairers	330	425	29
Gas and electric appliance repairers	62	72	17
Mainenance repairers	694	887	28
Office machine repairers	56	95	72
Radio and television service technicians	80	102	27
Telephone line installers	127	157	23

*Projected employment.

Source: Bureau of Labor Statistics, Monthly Labor Review (Nov. 1983).

SECTION IV. EMERGING TECHNICAL OCCUPATIONS

A variety of new occupational categories have emerged in recent years and many more will follow in the wake of technological change. Several of these jobs are based on traditional occupations that have been transformed by the application of computers while others are distinctively new occupations that have grown to meet the demands of an advanced technological society. At present it is difficult to clarify the future occupational composition of the work force or even identify all the new job classifications that will develop in response to these changes.

The occupations identified in this section are selected examples of the technical specialty jobs that occupational experts and futurists predict will provide jobs opportunities over the next decade. The descriptions are offered to provide insight into the changes that advanced technology is bringing to the world of work. Although in some cases employment and salary data are presented, it should be noted that these estimates are considered by many analysts to be highly speculative. In the interest of providing as much information about future jobs as possible, these data are presented but we caution readers to conduct further research regarding these and other new occupations before making career decisions. The statistics presented (unless otherwise noted) were developed by Clyde Helms and Marvin Cetron of Occupational Forecasting Inc.

NEW MANUFACTURING TECHNOLOGIES

As part of the research for the **Bridging the Skills Gap Project**, countless analyses were reviewed regarding the labor implications stemming from increased automation in the work place. Although we don't have the answer to the job displacement/creation debate, we think its important to have a basic understanding of developing industrial technologies. As a result we offer the following definitions of principal programmable automation technologies and identification of new occupational fields associated with these emerging fields. The technologies are grouped into three categories -- computer-aided design, computer-aided manufacturing and manufacturing management.

Computer-Aided Design

The Office of Technology Assessment (OTA) defines **computer-aided design (CAD)** as "an electronic drawing board for design engineers and drafters...These individuals work at a computer terminal, instructing the computer to combine various lines and curves to produce a drawing of a part of its specifications. In more complex forms, CAD can be used to communicate to manufacturing equipment the specifications and process for making a product-which engineers can analyze a design and maximize a product's performance using the computerized representation of the product."

The primary job associated with the use of this technology is **computer-aided design (CAD) technician (or operator).** CAD technicians perform a variety of computerized graphic duties in support of the design and production of custom products. The technician making printed circuit boards, for example, digitizes and enters into systems data required to generate logic and assembly circuit drawings. The stored information is edited and, as required, revised and updated to change existing drawings. CAD technicians operate equipment such as digitizer/plotter CRTs, tapes, and disk or cassette drives to produce circuit drawings. **CAD/CAM technicians** work with more complex computer programs that link the drafting function with actual manufacturing equipment.

The uniqueness of CAD technology is that it allows the designer to create and revise electronically the shape of a "drawing" and view it three-dimensionally from any angle. This important feature permits performance testing without producing expensive prototypes. It is anticipated that CAD applications will enhance the work of drafters, designers, engineers, architects, illustrators, blue print file clerks and others and be used in a variety of work settings within and outside the industrial sector. According to Occupational Forecasting Inc., "CAD will affect the education, employment and ways of work more than any other single technology."

Employment of CAD technicians has been forecast to reach 300,000 by 1990 with salaries beginning at $18,000 and averaging $30,000 for experience technicians and CAD specialists. Job requirements include a high school diploma and at least two years of technical training in computer-aided design and drafting. Experience in traditional drafting skills also benefits those entering the field.

Another specialty occupation related to CAD technology is **computer-aided engineering (CAE) technician.** The initial application of CAE technology has been in the automobile and aerospace industries where weight is a critical factor in product design. Specialized computer programs have been developed to minimize material needs while maintaining strength requirements. CAE programs are also used in the computer manufacturing industry to simulate the performance of a printed circuit board and check for errors as well as maximize the use of individual semiconductor chips.

The occupations associated with CAE technology are basically a new extension of the engineering technician occupational cluster (see Section I -- Engineering and Science Technicians). Consequently the basic educational and training requirements are comparable to those for engineering technicians combined with experience/skill in the use of computers. According to Occupational Forecasting Inc., employment by the early 1990s will reach 450,000 for CAE technicians with salaries beginning around $15,000 and reaching a mid-range of $27,000 per year.

In addition other computer-operator technician occupations associated primarily with manufacturing activities have been forecast to grow over the next decade. These jobs are related to **computer modeling and simulation** -- 300,000 jobs with salaries in the $25-40,000 range; **computer graphics** -- 150,000 jobs with annual wages around $30,000; **computer graphic input** -- 150,000 jobs with salaries averaging $25,000; and **computer-aided parts cataloging** -- 125,000 jobs with annual wages around $15,000.

Computer-Aided Manufacturing

Computer-aided manufacturing (CAM) is a general term that encompasses several forms of programmable automation. Primary CAM technologies include robots, numerically-controlled machine tools and flexible manufacturing systems.

Robots

The Robot Institute of America defines a **robot** as a "reprogrammable multifunctional manipulator designed to move material, parts, tools, or other specialized devices through variable programmed motions for the performance of a variety of tasks." The typical industrial robot is composed of three principal components: "hands" (mechanical system), "arms" (measuring system), and controllers (computer system).

Most robots are presently used for narrowly defined, repetitive tasks. **Table IV-A** presents examples of current robot applications. At present it is estimated that about 7,000 robots are used in the U.S. primarily in auto manufacturing. Based on factors such as cost (prices range from $25,000 - $80,000), development of applications technology and industry acceptance, estimates of robots that will be used in the U.S. by 1990 vary widely -- from 50,000 to 100,000 -- to even one million.

The primary job associated with this equipment is **robot technician** -- one who tests, programs, installs and/or maintains production lines of robots. Estimates of jobs are highly speculative and range from 25,000 to 800,000 by 1990. [The 800,000 figure seems extremely high given most estimates for robots in 1990.] Salaries for industrial robot production technicians are estimated to start at $15,000 and average about $24,000 for experienced workers. Job requirements for technicians working with robots are comparable to those for electronics technicians but also require additional experience/training in robotics and computers.

This particular occupation has captured the attention of many community colleges and vocational education institutions who appear to be gearing up training programs. Some experts in the field warn, however, that their may not be enough jobs to accom-

TABLE IV-A: Examples of Current Robot Applications

Material Handling:
- Depalletizing wheel spindles into conveyors
- Transporting explosive devices
- Packaging toaster ovens
- Stacking engine parts
- Transfer of auto parts from machine to overhead conveyor
- Transfer of turbine parts from one conveyor to another
- Loading transmission cases from roller convveyor to monorail
- Transfer of finished auto engines from assembly to hot test
- Processing of thermometers
- Bottle loading
- Transfer of glass from rack to cutting line

Machine loading/unloading:
- Loading auto parts for grinding
- Loading auto components into test machines
- Loading gears onto CNC lathes
- Orienting/loading transmission parts onto transfer machines
- Loading hot form presses
- Loading transmission ring gears onto vertical lathes
- Loading of electron beam welder
- Loading cylinder heads onto transfer machines
- Loading a punch press
- Loading die cast machine

Spray painting:
- Painting of aircraft parts on automated line
- Painting of truck bed
- Painting of underside of agricultural equipment
- Application of prime coat to truck cabs
- Application of thermal material to rockets
- Painting of appliance components

Welding:
- Spot welding of auto bodies
- Welding front-end loader buckets
- Arc welding hinge assemblies on agricultural equipment
- Braze alloying of aircraft seams
- Arc welding of tractor front weight supports
- Arc welding of auto axles

Machining:
- Drilling aluminum panels on aircraft
- Metal flash removal from casings
- Sanding missile wings

Assembly:
- Assembly of aircraft parts (used with auto-rivet equipment)
- Riveting small assemblies
- Drilling and fastening metal panels
- Assembling appliance switches
- Inserting and fastening screws

Other:
- Application of two-part urethane gasket to auto part
- Application of adhesive
- Induction hardening
- Inspecting dimensions on parts
- Inspection of hole diameter and wall thickness

SOURCE: Tech Tran Corp., *Industrial Robots: A Summary and Forecast*, 1983.

Reprinted from Computerized Manufacturing Automation: Employment, Education and the Workplace, Office of Technology Assessment (April 1984).

modate the number of trainees expected to complete these programs since it is unclear how quickly and to what extent robots will be introduced into factory and warehousing operations and how many workers will be required to operate, maintain and repair them.

Numerically-Controlled Machine Tools

Numerically-controlled (NC) machine tools are defined by the Office of Technology Assessment as "devices which cut a piece of metal according to programmed instructions about the desired dimensions of a part and the steps for the machining process. They consist of a machine tool, specially equipped with motors to guide the cutting process, and a controller which receives numerical control commands...[P]rograms are written at a terminal which, in turn, punches holes in a paper or mylar plastic tape." Typically these machines are not computerized, though the Japanese have recently introduced computerized versions of NC tools.

It should be noted that this particular form of programmable automation technology is not new to industrial setting. Certain forms of process control technology were introducted several years ago. The term "process control" is used to describe automation of simple as well as complex manufacturing processes. Singular metal working tasks, for example, have been performed by numerically-controlled (NC) machine tools for years. Recent developments have led to reprogrammable NC machine tools which can perform multiple functions.

There are two major occupational categories associated with numerically controlled machine tools -- **operators and programmers.** Bureau of Labor Statistics (BLS) data indicate there were 66,000 workers employed as NC machine tool operators and 7,000 NC machine tool programmers during 1982. Last year the BLS projected employment for operators may reach 95,000 by 1995 or grow by 44%. Comparable data for programmers were not reported but it is assumed that job growth for this occupation will also occur. Although this increase in employment appears promising, actual job opportunities may be limited based on the transference of skilled non-NC tool operators into these occupations (after obtaining additional training); and the health of the industries that employ these workers.

The traditional skills of **machine tool operators** include planning and setting up the correct sequence of machining operations according to blue prints, layouts and other instructions. These workers adjust speed, feed and other controls and select the proper cutting instruments or tools for each operation. Using micrometers, gauges and other precision measuring instruments, they compare the completed work with the tolerance limits govem to the specificiations. They may also select cutting fluids to keep the metal workpiece from getting too hot, and lubricants to keep the machine tools running smoothly.

Most machine tool operators learn their skills on the job either by observing experienced operators or through employer training programs. Although educational requirements may be minimal (a high school diploma or equivalent is often required), employers prefer workers who have completed courses in mathematics and blue print reading. Mechanical ability and experience working with machinery can also be critical hiring factors. The occupation of **NC machine tool operator** is considered a skilled occupation (the majority of machine tool operators are classified as semi-skilled laborers) and many workers enter the occupation through participation in apprenticeship programs. NC machine tool programmers require more formal technical training. Annual wages for experienced NC tool operators and programmers are in the $18-25,000 range.

Flexible Manufacturing Systems

FMS or **flexible manufacturing systems** are the most recent development in computer-aided manufacturing. These systems consist of one or more computer-controlled machine tool, other machinery, automated material handling systems (e.g. robots) -- all controlled by a central computer. According to the OTA, FMS "consists of production equipment workstations (machine tools or other equipment for fabrication, assembly or treatment) linked by a materials handling sytem to move parts from one workstation to another, and it operates as an integrated system under full programmable control."

FMS technology is a relatively new manufacturing concept and requires significant investment in plant and equipment (roughly $10 million per facility). It has been estimated that there are about 30 FMS installations currently in operation in the U.S. Although no specific occupational titles are yet associated with FMS, technicians specializing in CAD/CAM, robotics, and other related technologies will be among those staffing these kinds of installations. In addition, highly skilled professionals and interdisciplinary teams of workers in engineering, programmable automation technologies, industrial processes and equipment, and related fields will perform significant roles.

Manufacturing Management

Tools and strategies associated with manufacturing management include computer-integrated manufacturing, management information systems and computer-aided planning.

"**Computer-integrated manufacturing (CIM)** involves the integration and coordination of design, manufacturing, and management using computer-based systems. CIM is not yet a specific technology that can be purchased, but rather an approach to factor organization and management," according to the Office of Technology

Assessment. The ideal CIM network covers all functional areas of manufacturing including design, storage and retrieval of information, management and control of resources (e.g. labor, machines and materials) according to changing demands, handling of materials, and control of machine tools machinery and robots. CIM is a technological concept of the future that could be applied to a broad range of discrete products manufacture in such indistries as aircraft, computers, furniture, food, clothing and building materials as well as autos and machine tools but its refinement, acceptance and implementation will depend upon a variety of technological and economic factors and decisions.

Other examples of developing computer-based manufacturing management technologies include **management information systems (MIS) --** complex computer programs that maintain and summarize very large data bases pertaining to all aspects of business, e.g. designs, inventory, orders, machine capabilities, personnel, materials costs, finances, etc.; **computer-aided planning (CAP) --** computer systems that are designed to utilize plant resources efficiently and optimize decisions in factory operation; and **computer-assisted processing planning (CAPP) --** computer programs used by production planners to establish optimal sequence of production operations for a given output/product.

"SUPER TECHNICIANS"

In general there are two distinct classes of occupations developing from the introduction of new microelectronic technologies. The first group is related to the research and development of the equipment and systems. These jobs require advanced education and training in engineering and computer sciences. The second group is associated with the use of the equipment and systems -- the technician and operator occupations. These jobs will require in the majority of cases technicial education or training beyond the high school level. Competition no doubt will be stiff for the jobs identified with the above (especially the technician group) and the many others that will emerge from the introduction of new technologies in industry as well as other sectors of the economy. At present the high tech dialogue (as it relates to occupational needs) focuses on both these groups although the future needs of employers and the greater source of jobs will come largely from the second category.

Industrial technicians working with automated equipment and/or computerized management systems must be able to use both the hardware and software of computers and digital machinery. The development, installation, programming and repair of most computerized equipment requires a combination of knowledge and skills in computer programming and digital electronics. Given the movement towards a systems approach to manufacturing, it will become increasingly important for technicians who work with high tech equipment to have a broad technical background.

According to the American Vocational Association (AVA) and the Center for Occupational Research and Development (CORD) the greatest occupational demand of the future will be for the **super tech** who can install, operate, maintain and repair systems that may incorporate combinations of electrical motors, digital circuits, mechanisms, hydraulic actuators, lenses, light sources and transducers. In response to the need to educate technicians with interdisciplinary skills these organizations are promoting curricula for vocational and technical education programs that provide a common core of courses in basic skills and technologies combined with a specialty core of coursework related to a particular high technology area. This concept takes into account not only the increasing interdisciplinary requirements of many jobs but also the realization that frequent changes in technology may potentially render specialized skills obsolete.

The following outlines the AVA/CORD recommendations for vocational and technical institutions preparing future high tech workers.

TABLE IV-B. Proposed High Technology Curriculum Structure

Basic Skills
- Mathematics
- Science
- Communications
- Computer Literacy
- Socioeconomics

Technical Core
- Electricity
- Electronics
- Mechanics
- Electromechanics
- Materials
- Fluids
- Thermics
- Graphics
- Controls
- Computers

Specialty Areas

Computers
- Digital fundamentals
- Active devices and circuits
- Digital devices and systems
- Analog devices and systems
- Computer circuits and programming
- Digital computers

Automated Manufacturing
- Manufacturing tools, fixtures and measurements
- CAD/CAM system hardware and functions
- CNC programming
- Fundamentals of robotics
- Automated integrated manufacturing systems

This type of approach to education can also be applied to technical occupations that are not necessarily based in industry such as computer-aided drafting, computer service technicians and a host of other developing occupational fields where employment requirements demand core skills combined with expertise in specialty areas.

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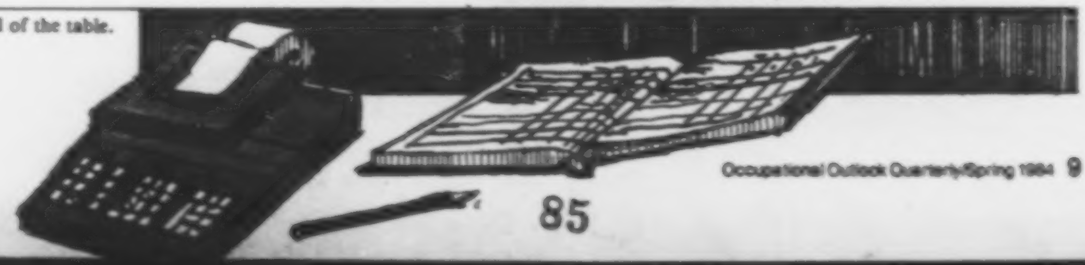
APPENDIX A

The Job Outlook in Brief

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982-95[1]	Numerical change in employment 1982-95[1]	Employment prospects
ADMINISTRATIVE AND MANAGERIAL OCCUPATIONS				
Accountants and auditors	856,000	40	344,000	Employment expected to increase faster than average as managers rely more on accounting information to make business decisions. College graduates will be in greater demand than applicants who lack this training.
Bank officers and managers	424,000[2]	45	193,000	Employment expected to grow faster than average as banks expand services. Competition for managerial positions likely to stiffen. Familiarity with computers and other data processing equipment may enhance employment opportunities.
Buyers, retail and wholesale trade	256,000	30	76,000	Employment expected to grow about as fast as average. However, keen competition anticipated because merchandising attracts large numbers of college graduates.
Construction inspectors, public administration	39,000	17	6,800	Employment expected to grow more slowly than the average despite the anticipated increase in construction activity. Best prospects for highly experienced craft workers who have some college training or who are certified.
Health services administrators	303,000[2]	58	175,000	Employment expected to grow much faster than average as health industry expands and management becomes more complex. Management experience or a graduate degree in health administration, business, finance, information management, or a related field is required for many jobs.
Health and regulatory inspectors	101,000	7	6,600	Employment expected to grow more slowly than the average as government programs and spending increase modestly.
Hotel managers and assistants	67,000[2]	23	15,000	Employment expected to grow about as fast as average. Best opportunities for persons with a degree in hotel administration.
Personnel and labor relations specialists	203,000	23	47,000	Employment expected to grow about as fast as average as employers implement human resource development and other employee programs to raise productivity. Keen competition for jobs in labor relations.
Purchasing agents	191,000	27	52,000	Employment expected to grow about as fast as the average. Best opportunities for persons with a master's degree in business administration; graduates of 2-year programs in purchasing should find good opportunities in small firms.
School administrators	133,000	15	20,000	Employment expected to grow more slowly than average. Competition expected as other school personnel attempt to move into administrative jobs.
Underwriters	76,000	21	16,000	Employment expected to grow about as fast as average as insurance sales continue to expand and insurance companies introduce new types of insurance and evaluate risks more frequently.

Notes appear at the end of the table.



Job Outlook

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982-95[1]	Numerical change in employment 1982-95[1]	Employment prospects
ENGINEERS, SURVEYORS, AND ARCHITECTS				
Architects	84,000	40	33,000	Employment expected to rise faster than average. However, growth may not be as fast as in previous years due to increased use of computers and lower foreign demand for U.S. architectural services. Keen competition is expected for jobs in the most prestigious firms.
Surveyors	44,000	43	19,000	Employment expected to grow faster than average due to increased construction activity.
Engineers				
Engineers	1,204,000[3]	49	584,000	Employment expected to grow faster than average. More engineers will be needed to design industrial plants and equipment, develop defense-related products, and improve transportation systems. Good employment opportunities for graduates with an engineering degree.
Aerospace engineers	44,000	41	18,000	Employment expected to increase faster than average due to increased expenditures for military and commercial aircraft.
Chemical engineers	56,000	43	24,000	Employment expected to grow faster than the average. Economic expansion and increasing complexity and automation of chemical processes will require additional chemical engineers to design, build, and maintain plants and equipment.
Civil engineers	155,000	47	73,000	Employment expected to increase faster than average. Population and economic growth will increase the need for civil engineers to design and construct transportation systems, manufacturing plants, and other structures.
Electrical engineers	320,000	65	209,000	Employment expected to increase much faster than average due to growing demand for computers, communications equipment, military-electronics, and electrical and electronic consumer goods.
Industrial engineers	160,000	42	67,000	Employment expected to grow faster than average due to industry growth, increasing complexity of industrial operations, expansion of automated processes, and greater emphasis on scientific management and safety engineering.
Mechanical engineers	209,000	52	109,000	Employment expected to increase much faster than average due to growing demand for industrial machinery as well as the need to develop new energy systems and to reduce pollution.
Metallurgical engineers	14,000	47	6,600	Employment expected to grow faster than average because of the need to develop new metals and alloys, adapt current ones to new needs, and imporve ways of recycling solid waste and processing low-grade ores.
Mining engineers	5,700	22	1,300	Employment expected to grow about as fast as average as a result of efforts to attain energy self-sufficiency and to develop better mining systems.
Nuclear engineers	6,300	48	3,000	Employment expected to grow faster than average because of the need to operate nuclear power plants and to improve and enforce safety standards.
Petroleum engineers	26,000	22	5,700	Employment expected to grow about as fast as average because, as oil and gas become increasingly hard to find, more petroleum engineers will be needed to develop new sources of oil and gas and more sophisticated recovery methods.

Notes appear at the end of the table.

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982-95[1]	Numerical change in employment 1982-95[1]	Employment prospects
NATURAL SCIENTISTS AND MATHEMATICIANS				
Mathematical scientists and systems analysts				
Actuaries	8,200	33	2,700	Employment expected to rise faster than average as insurance sales increase and insurance companies introduce new forms of insurance and reevaluate existing health and pension plans. Best opportunities for college graduates who have passed at least two actuarial exams while still in school and have a strong mathematical and statistical background.
Computer systems analysts	254,000	85	217,000	Employment expected to grow much faster than average as computer capabilities are increased and computers are used to solve a greater variety of problems. College graduates with courses in programming and systems analysis and training and experience in applied fields will have the best prospects.
Mathematicians	11,000	28	3,000	Employment expected to grow about as fast as average. Best opportunities for holders of advanced degrees, especially in applied mathematics and computer sciences.
Statisticians	20,000	28	5,700	Employment expected to grow about as fast as average as use of statistics expands. Persons combining knowledge of statistics with a field of application, such as engineering or physical sciences, can expect favorable job opportunities.
Physical scientists				
Chemists	89,000	22	20,000	Employment expected to grow about as fast as average. Most openings are expected to be in private industry, primarily in the development of new products. Industrial companies will need more chemists—especially biochemists—to work in biotechnology research, development, and production.
Geologists and geophysicists	49,000	24	11,000	Employment expected to grow about as fast as average due to efforts to locate new sources of energy. Best prospects for those with knowledge and experience in geophysical oil and gas exploration techniques.
Meteorologists	3,700	14	500	Employment expected to increase more slowly than average. Little or no growth in employment expected in the National Weather Service, which employs most meteorologists.
Physicists	19,000	37	6,900	Employment expected to grow faster than average. Opportunities expected to be good for Ph.D.'s
Life scientists				
Agricultural scientists	22,000	19	4,000	Employment expected to grow more slowly than average due to limited growth in government programs. Application of biotechnology to agriculture may cause rapid employment growth in research work in private industry.
Biological scientists	52,000	36	19,000	Employment expected to increase faster than average due to increased research and development in biotechnology.
Foresters and conservationists	31,000	9	2,900	Employment expected to grow more slowly than average. Employment should continue to grow faster in private industry than in Federal and State governments.

Job Outlook

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982-95[1]	Numerical change in employment 1982-95[1]	Employment prospects
SOCIAL SCIENTISTS, SOCIAL WORKERS, RELIGIOUS WORKERS, AND LAWYERS				
Lawyers	465,000	34	159,000	Employment expected to grow faster than average as demand for legal services increases. Keen competition is likely for salaried positions. Best prospects for establishing new practices will be in small towns and expanding suburbs.
Social scientists and urban planners				
Economists	30,000	27	8,000	Employment expected to grow about as fast as average. Overall, economists have better job prospects than other social scientists. Best opportunities for those trained in quantitative methods. Ph.D.'s face competition for academic positions, but can expect good opportunities in nonacademic areas. Persons with master's and bachelor's degrees likely to face keen competition for economist jobs, but many will find research, managerial, and administrative jobs.
Psychologists	83,000	33	27,000	Employment expected to grow faster than average. Graduates face increasing competition, particularly for academic positions. Best prospects for doctoral degree holders trained in applied areas, such as clinical, counseling, health, and industrial psychology.
Sociologists	5,700	25	1,400	Employment expected to grow about as fast as average. Ph.D.'s face competition, particularly for academic positions. Best opportunities for Ph.D.'s trained in quantitative research techniques and applied sociology. Very keen competition below the Ph.D. level.
Urban and regional planners	21,000	15	3,100	Employment expected to grow more slowly than the average due to limited growth of local government spending. Best job prospects for applicants who are willing to relocate, especially to small towns or rural areas.
Social and recreation workers				
Social workers	345,000	21	71,000	Employment expected to increase about as fast as average. Keen competition in areas with many schools of social work. Best opportunities in rural areas and in areas with rapid employment growth. Market for Master's of Social Work likely to improve if the number of social work students continues to decline.
Recreation workers	124,000	23	28,000	Employment expected to grow about as fast as average as organized leisure activities increase. Strong growth foreseen in commercial recreation. Applicants for jobs in public or voluntary agencies are likely to encounter keen competition.
Religious workers				
Protestant ministers	243,000	([illegible])	([illegible])	Increasing competition is expected for positions in large congregations. Better opportunities for ministers willing to work in rural areas.
Rabbis	6,500	([illegible])	([illegible])	Favorable job prospects expected for Reform, Reconstructionist, and Conservative rabbis. Orthodox rabbis are expected to encounter keen competition.
Roman Catholic priests	58,000	([illegible])	([illegible])	Shortage of priests as supply of seminary graduates fails to keep pace with growing Catholic population.

Notes appear at the end of the table.

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982–95[1]	Numerical change in employment 1982–95[1]	Employment prospects
TEACHERS, LIBRARIANS, AND COUNSELORS				
Kindergarten and elementary school teachers	1,366,000	37	511,000	Employment expected to grow faster than average due to rising enrollments. Job prospects are expected to begin improving during the mid-1980's.
Secondary school teachers	1,024,000	13	128,000	Employment expected to grow more slowly than the average. Keen competition expected through early 1990's as enrollments and teacher employment decline. Opportunities should improve after 1990 as enrollments start rising. Generally favorable opportunities will exist for persons qualified to teach special education, vocational subjects, mathematics, sciences, and bilingual education.
College and university faculty	744,000	−15	−111,000	Employment expected to decrease due to declining enrollments and budgetary constraints. Keen competition in all but a few disciplines; many of the available openings will be part time or short term. Good job prospects for engineering and computer science faculty.
Counselors	148,000	10	15,000	Employment expected to grow more slowly than the average. Limited opportunities in schools. Best job opportunities expected in private practice, community and social service agencies, and personnel offices in private business.
Librarians	151,000	13	19,000	Employment expected to grow more slowly than average, but job prospects may improve if the number of library school graduates continues to decline and employment opportunities outside the traditional library setting increase. Best opportunities for librarians with scientific or technical qualifications.
HEALTH DIAGNOSING AND TREATING PRACTITIONERS				
Chiropractors	25,000	27	6,900	Employment expected to grow about as fast as average as chiropraxis enjoys broader public recognition. Competition may grow as the number of practitioners increases. Selection of location may become more inportant for establishing a successful practice.
Dentists	173,000	24	41,000	Employment expected to grow about as fast as average due to population growth, increased awareness of importance of dental care, and prepayment arrangements. Increasingly abundant supply of practitioners will make it more difficult to start a practice. Competition for patiens is likely to be intense in some localities, which could adversely affect earnings.
Optometrists	28,000	25	6,900	Employment expected to grow about as fast as average due to theeye care needs of a growing and aging population, greater awareness of vision problems as a result of screening programs, and rising per capitaincome. Employment prospects will be favorable.
Physicians	479,000	34	163,000	Employment expected to grow faster than average as demand fir health care continues to outpace overall economic growth. Despite the rse in demand, some physicians will encounter competition for patients because the number of practitioners is projected to grow substantially. Earnings may be adversely affected, and an increasing number of physiians are likely to accept salaried positions.
Podiatrists	13,000	52	6,700	Employment expected to grow much faster than average as brod public recognition of the profession causes more people to tura to podiarists for foot care. Widespread participation in fast-moving sports, including jogging and tennis, and the growing number of elderly will also spur demand. Opportunities to establish new practices or to enter salared positions should be favorable.
Veterinarians	36,000	30	11,000	Employment expected to grow faster than average. New veteinarians may experience competition in setting up a practice in some plces, but opportunities for specialists, including toxicologists and pathologsts, will be excellent.

Job Outlook

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982–95[1]	Numerical change in employment 1982–95[1]	Employment prospects
REGISTERED NURSES, PHARMACISTS, DIETITIANS, THERAPISTS, AND PHYSICIAN ASSISTANTS				
Dietitians	44,000	40	18,000	Employment expected to grow faster than average in response to increasing concern for proper nutrition. Favorable opportunities, both full- and part-time, for those having appropriate training and clinical experience.
Occupational therapists	25,000	60	15,000	Employment expected to increase much faster than average due to rapidly growing demand for rehabilitation services. Job prospects should be excellent.
Pharmacists	151,000	27	41,000	Employment expected to grow about as fast as average due to the growth and aging of the population, the rapidly increasing demand for pharmacy services in health care facilities, the wider range of drug products available, and the extensive coverage for prescription drugs provided by health insurance. Employment prospects are generally favorable, but keen competition is likely in some localities.
Physical therapists	43,000	58	25,000	Employment expected to grow much faster than average because of rapidly growing demand for rehabilitation services. Job prospects expected to be very good.
Physician assistants	22,000	27	6,000	Employment expected to grow as fast as average, reflecting expansion of health industry and advanced skills required to apply complex medical technology. The number of staff jobs in hospitals is expected to grow. Although demand for new graduates remains strong, the growing supply of physicians and restrictions on payment for services of physician assistants could slow future growth.
Registered nurses	1,312,000	49	642,000	Employment expected to grow faster than average due to health care needs of a growing and aging population. Major factors spurring demand will be the complexity of hospital-based medical procedures and equipment; the rapid growth of clinics, freestanding emergency centers, surgicenters, corporate wellness centers, and other health care facilities; and staffing needs of nursing homes and home health programs.
Respiratory therapists	46,000	45	21,000	Employment expected to grow faster than average due to the importance of respiratory therapy in diagnosis, treatment, and care of patients with cardiopulmonary problems. Opportunities should be excellent for experienced therapists and for graduates of accredited programs.
Speech pathologists and audiologists	42,000	29	12,000	Employment expected to increase about as fast as average. Emphasis on early recognition and treatment of speech and hearing problems in children will continue to stimulate demand in schools.

Notes appear at the end of the table.

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CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982-95[1]	Numerical change in employment 1982-95[1]	Employment prospects
HEALTH TECHNOLOGISTS AND TECHNICIANS				
Clinical laboratory technologists and technicians	209,000	40	83,000	Employment expected to grow faster than average due to the importance of laboratory tests in medical diagnosis and treatment, the health care needs of a growing and aging population, and broad coverage of clinical laboratory services under public and private health insurance.
Dental hygienists	69,000	43	30,000	Employment expected to grow faster than average because of expanding population and growing awareness of importance of regular dental care. However, if the increasing supply of dentists leads to smaller patient loads, dentists may choose to perform more services themselves and hire fewer hygienists.
Electrocardiograph technicians	21,000	37	7,700	Employment expected to grow faster than average because of the importance of the electrocardiograph in diagnosing heart disease and monitoring cardiac conditions. Opportunities will be best for those with postsecondary school training.
Electroencephalographic technologists	5,500	41	2,300	Employment expected to grow faster than average due to the use of EEG's in surgery, diagnosis, monitoring patients with brain disease, and research. Opportunities are expected to be best for registered technologists and those with formal training.
Health record technicians	22,000	43	9,400	Employment expected to grow faster than average due to the vast amount of paperwork associated with health care and changes in hospital recordkeeping procedures in response to the new Medicare reimbursement system that will require more accurate and complete medical records. The outlook for technicians with a 2-year associate degree is excellent.
Licensed practical nurses	594,000	37	220,000	Employment expected to grow faster than average as demand for health care continues to grow rapidly. Many job openings are expected in nursing homes, home health agencies, and private duty nursing.
Radiologic technologists	110,000	43	47,000	Employment expected to grow faster than average as new uses are found for "imaging" technologies in the diagnosis and treatment of diseases. Opportunities should be generally favorable, with strong demand for radiation therapy technologists and nuclear medicine technologists in many areas.
Surgical technicians	35,000	40	14,000	Employment expected to grow faster than average due to the increasing number of operations and expanding role of surgical technicians. Prospects will be best for graduates of formal training programs or certified surgical technicians.
WRITERS, ARTISTS, AND ENTERTAINERS				
Communications occupations				
Public relations specialists	90,000	29	26,000	Employment expected to grow about as fast as average as corporations, associations, medical centers, and other large organizations expand public relations efforts. Competition for jobs is likely to be keen.
Radio and television announcers and newscasters	55,000	28	15,000	Employment expected to increase about as fast as average as new stations are licensed and as more cable television systems develop their own programming. Keen competition is likely for openings, however. Best prospects are expected in small cities and towns.
Reporters and correspondents	51,000	29	15,000	Employment expected to grow about as fast as average. Best opportunities are likely to be found on newspapers and magazines in small towns and suburbs and for journalism graduates who have specialized in news-editorial studies and completed an internship.
Writers and editors	120,000	35	42,000	Employment expected to increase faster than average due to increased demand for salaried writers in publishing, communications, advertising, and other industries. Keen competition is expected to continue. Job prospects should be best in technical writing and business and trade publications.

Job Outlook

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CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982-95[1]	Numerical change in employment 1982-95[1]	Employment prospects
WRITERS, ARTISTS, AND ENTERTAINERS—continued				
Design occupations				
Commercial and graphic artists and designers	133,000	26	34,000	Keen competition expected to continue. Those with above average talent and skills will be in demand.
Designers	180,000	41	73,000	Employment is expected to grow faster than the average. However, because many people are attracted to the field, stiff competition is expected, except in floral design.
Photographers	86,000	18	16,000	Employment expected to grow more slowly than average. Portrait and commercial photographers are likely to face keen competition. Areas such as law enforcement and scientific and medical research photography should offer the best opportunities.
Performing artists				
Actors and actresses	34,000	43	15,000	Employment expected to grow faster than average, but overcrowding in this field will persist.
Dancers	7,700	43	3,300	Although employment expected to grow faster than the average, keen competition is expected to continue.
Musicians	124,000	25	31,000	Although employment expected to grow about as fast as average, keen competition is expected to continue.
Singers	21,000	21	4,400	Employment expected to grow about as fast as the average, but keen competition is expected to continue.
TECHNOLOGISTS AND TECHNICIANS EXCEPT HEALTH				
Air traffic controllers	21,000	4	900	Despite the increase in the number of aircraft, employment is expected to show little or no change because of the greater use of automated control equipment. Keen competition is expected; opportunities are best for college graduates and those with experience as controllers, pilots, or navigators.
Broadcast technicians	17,000	27	4,500	Employment expected to increase about as fast as average as new radio and television stations are licensed and as more cable television systems develop their own programs. Job competition will continue to be keen, however, and prospects will be best in small cities and towns.
Computer programmers	266,000	77	205,000	Employment expected to grow much faster than average as computer usage expands. Prospects will be best for college graduates with majors in computer and information science and experience or training in fields such as accounting, management, engineering, or science. People with a 2-year degree or less training and no experience may face competition.
Drafters	302,000	5	15,000	Little change expected in employment despite industrial growth and increasingly complex design problems. Widespread use of computer-aided design equipment will greatly increase productivity.

Notes appear at the end of the table.

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CLUSTER **Subgroup** **Occupation**	**Estimated employment 1982[1]**	**Percent change in employment 1982–95[1]**	**Numerical change in employment 1982–95[1]**	**Employment prospects**
Electrical and electronics technicians	366,000	61	222,000	Employment expected to increase much faster than the average due to increased demand for computers, communications equipment, military electronics, and electronic consumer goods. Opportunities will be best for graduates of post-secondary technical programs.
Legal assistants	45,000	94	43,000	Employment expected to grow much faster than average as the use of legal assistants to aid lawyers increases. Prospects are likely to be best for persons with formal legal assistant training.
Library technicians	29,000	10	3,000	Employment expected to grow more slowly than the average. Best job prospects are likely to be in special libraries.
Tool programmers, numerical control	12,000	78	9,700	Employment expected to rise much faster than the average due to the increased use of numerical control and other types of automated machining equipment.
MARKETING AND SALES OCCUPATIONS				
Cashiers	1,570,000	47	744,000	Plentiful job opportunities expected as employment grows faster than average and replacement needs remain high. many openings will be part time.
Insurance agents and brokers	361,000	25	90,000	Employment expected to grow about as fast as average as insurance sales expand. Opportunities will be best for ambitious persons who enjoy selling and develop expertise in many different types of insurance and investments.
Manufacturers' sales workers	414,000[2]	15	64,000	Employment expected to grow more slowly than the average, as some manufacturers switch to wholesalers to sell their products.
Real estate agents and brokers	337,000	33	112,000	Employment expected to rise faster than average in response to growing demand for housing and other properties. However, the field is highly competitive. Well-trained, ambitious people who enjoy selling should have the best chance for success.
Retail trade sales workers	3,367,000[2]	27	898,000	Employment expected to grow about as fast as average. High turnover should create many openings for full-time, part-time, and temporary workers.
Securities sales workers	78,000	36	28,000	Employment expected to grow faster than average as economic growth and rising personal incomes increase the funds available for investment. However, the field will continue to be competitive, and many beginners may be unable to establish a sufficient clientele.
Travel agents	62,000	43	26,000	Employment expected to grow faster than average. Because travel expenditures often depend on business conditions, job opportunities are sensitive to economic changes.
Wholesale trade sales workers	1,093,000	30	327,000	Employment expected to grow slightly faster than average as wholesalers sell a wider variety of products and improve customer services.

Job Outlook

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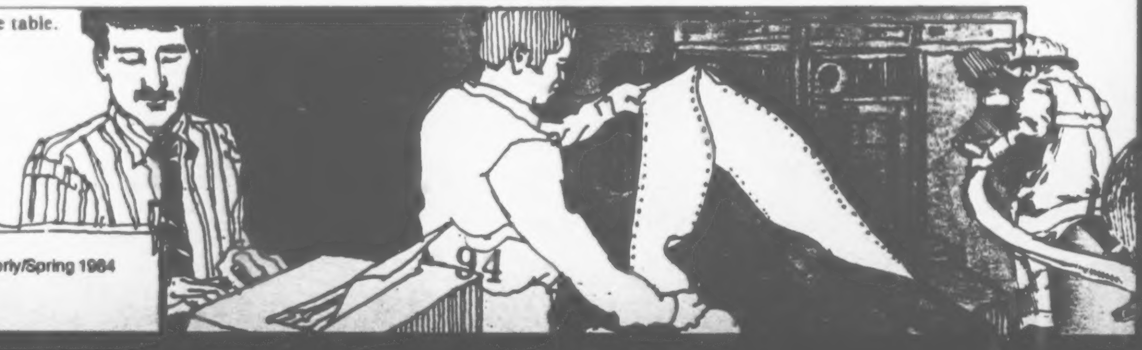
CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982–95[1]	Numerical change in employment 1982–95[1]	Employment prospects
ADMINISTRATIVE SUPPORT OCCUPATIONS, INCLUDING CLERICAL				
Bank tellers	539,000	29	154,000	Employment expected to grow about as fast as average. Full time and part time job openings should be plentiful.
Bookkeepers and accounting clerks	1,713,000	16	272,000	Employment expected to grow more slowly than average due to technological change such as the increased use of computers. Nevertheless, because the occupation is so large, job openings will be numerous.
Computer operating personnel	580,000	27	157,000	Employment of computer and peripheral equipment operators expected to rise much faster than average as the use of computers expands. Employment of data-entry operators is expected to decline, however, due to the use of more efficient direct data entry techniques.
Mail carriers	234,000	−5	−11,000	Little change expected in employment as new routing programs and more centralized mail delivery offset the growing volume of mail.
Postal clerks	307,000	−18	−55,000	Employment expected to decline due to increasing automation of mail processing. Keen competition anticipated for jobs.
Receptionists	594,000	45	267,000	Employment expected to grow faster than average as business, personal, and professional services expand. Job prospects should be most favorable for those with typing and other office skills.
Reservation agents and transportation ticket agents	108,000	2	2,100	Little change expected in employment as automation and other changes improve productivity. Competition is anticipated for jobs.
Secretaries	2,441,000	29	719,000	Employment expected to grow about as fast as average despite the spread of office automation, reflecting information processing needs of rapidly growing industries including business services, finance, and health care. Numerous job opportunities are expected because the occupation is so large. Prospects for part-time and temporary work are likely to be excellent.
Shipping and receiving clerks	365,000	18	66,000	Employment expected to increase more slowly than average due to automation and the concentration of these clerks in slow-growing industries, principally manufacturing and wholesale trade. Many job opportunities are nonetheless expected because the occupation is large.
Stenographers	270,000	−7	−20,000	Employment expected to decline; however, demand should be strong for court reporters.
Teacher aides	463,000	28	130,000	Employment expected to grow about as fast as average as enrollments begin to rise in elementary schools in the mid-1980's and in secondary schools after 1990. Continued emphasis on special education will also increase demand for aides.
Telephone operators	323,000	8	25,000	Employment expected to grow more slowly than average due to the introduction of new technology.
Typists	990,000	16	155,000	Employment expected to increase more slowly than the average, due to office automation. Numerous job openings are anticipated because of the large size of the occupation. Demand is likely to be particularly strong for typists who can handle a variety of office duties and operate word-processing equipment.

Notes appear at the end of the table.



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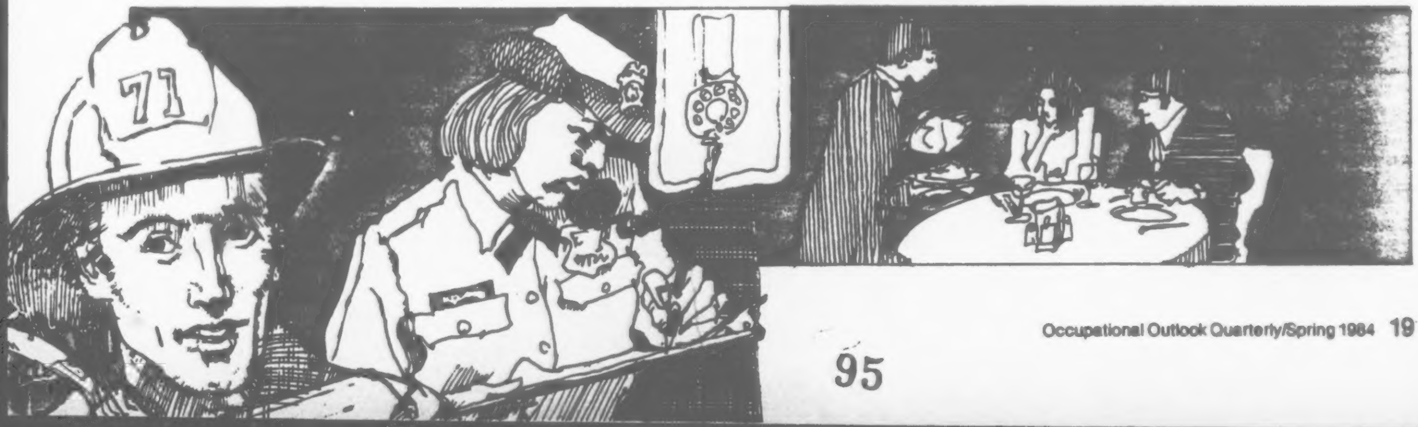
CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982–95[1]	Numerical change in employment 1982–95[1]	Employment prospects
SERVICE OCCUPATIONS				
Protective service occupations				
Correction officers	111,000	33	36,000	Employment expected to increase faster than average as correctional facilities expand and additional officers are hired to provide closer supervision of inmates.
Firefighters	252,00	9	22,000	Employment expected to increase more slowly than the average as slow growth in local government spending limits employment growth. Keen competition is likely for jobs in urban areas; better opportunities in smaller communities.
Guards	637,000	47	300,000	Employment expected to grow faster than average due to increased concern over crime and vandalism. Opportunities are likely to be best in guard and security agencies and on night shifts.
Police and detectives, public service	549,000	8	43,000	Employment expected to rise more slowly than the average as slow growth in local government spending limits employment growth. Keen competition is expected with prospects best for applicants who have some college training in law enforcement.
Food and beverage preparation and service occupations				
Bartenders	384,000	32	121,000	Employment expected to grow faster than the average as many new bars, hotels, and restaurants open. Job opportunities expected to be plentiful.
Cooks and chefs	1,211,000	33	402,000	Employment expected to grow faster than the average as population growth, higher incomes, and more leisure time allow people to dine out more. Particularly fast growth is expected in institutions serving the expanding elderly population.
Waiters and waitresses	1,665,000	34	562,000	Employment expected to grow faster than the average as dining out increases. High job turnover in this very large occupation will result in numerous full-time and part-time job openings.
Health service occupations				
Dental assistants	153,000	42	64,000	Employment expected to grow faster than average because of greater demand for dental care and dentists' desire to increase productivity by using assistants for routine tasks. If the abundant supply of dentists leads to lower patient loads, however, dentists may hire fewer assistants and employment would grow more slowly than currently anticipated.
Medical assistants	100,000	47	48,00	Employment expected to grow faster than average due to an increase in the number of physicians. Very good job prospects are expected for medical assistants with formal training, experience, or both.
Nursing aides, orderlies, and attendants	1,218,000	35	423,000	Employment expected to grow faster than average due to increasing demand for health care of a larger and longer-living population. Numerous job openings are expected, especially in nursing homes and other long-term care facilities.



Job Outlook

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982–95[1]	Numerical change in employment 1982–95[1]	Employment prospects
SERVICE OCCUPATIONS—continued				
Cleaning service occupations				
Building custodians	2,828,000	28	779,000	Employment expected to grow about as fast as average as the number of office buildings, factories, hospitals, schools, apartment houses, and other buildings increases.
Personal service occupations				
Barbers	115,000	10	12,000	Employment expected to grow more slowly than average. Job prospects are best for hairstylists.
Cosmetologists	519,000	20	103,000	Employment expected to grow about as fast as average as demand for beauty shop services rises. Opportunities for part-time work should be very good.
Flight attendants	54,000	29	15,000	Employeent expected to grow about as fast as average as airline travel increases. Competition for jobs is likely to remain very keen.
MECHANICS AND REPAIRERS				
Vehicle and mobile equipment mechanics and repairers				
Aircraft mechanics	108,000	19	20,000	Employment expected to grow more slowly than the average due to labor-saving advances in aircraft maintenance. Opportunities will be best in general aviation; keen competition is expected for airline jobs. Opportunities in the Federal Government depend upon defense spending.
Automotive body repairers	155,000	26	41,000	Employment expected to increase as fast as average due to growing numbers of vehicles and traffic accidents.
Automotive mechanics	844,000	38	324,000	Employment expected to increase faster than average due to the growing number of automobiles. Job opportunities will be plentiful for persons with formal training.
Diesel mechanics	173,000	28	48,000	Employment expected to increase about as fast as average due to the growing use of diesel-powered trucks, automobiles, and equipment. Opportunities are best for persons who complete formal training.
Farm equipment mechanics	26,000	5	1,400	Little or no change in employment is expected as growth in use of farm equipment is slowed by the continued consolidation of farmland into fewer and larger farms. Best opportunities for persons with formal training.
Electrical and electronic equipment repairers				
Appliance installers and repairers	80,000	17	13,000	Employment expected to grow more slowly than average as the increasing use of electronic parts lessens the need for repairers. Job prospects are best for those with a strong background in electronics.
Communications equipment mechanics	92,000	3	3,000	Little change in employment expected as technological improvements limit growth.
Computer service technicians	55,000	97	53,000	Employment expected to grow much faster than average as more computer equipment is used.
Line installers and cable splicers	195,000	27	53,000	Employment expected to grow about as fast as average due to increasing demand for electricity and telephone service by a growing population.
Radio and television service technicians	80,000	27	22,000	Employment expected to increase about as fast as average as the number of home electronic products such as television sets, video games, radios, phonographs, and tape and video recorders increases.
Telephone and PBX installers and repairers	134,000	28	37,000	Employment expected to grow about as fast as average due to the increasing amount of telephone equipment in use. Prospects are likely to be best for persons able to work with PBX, CENTREX, and other sophisticated systems.

Notes appear at the end of the table.

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982–95[1]	Numerical change in employment 1982–95[1]	Employment prospects
Other mechanics and repairers				
Air-conditioning, refrigeration, and heating mechanics	168,000	33	55,000	Employment expected to increase faster than average. Beginning mechanics may face competition for the highest paying jobs. Graduates of training programs that emphasize hands-on experience will have the best opportunities.
Coin machine servicers and repairers	31,000	28	8,700	Employment expected to grow about as fast as average due to the growing number of coin-operated machines in service. Excellent prospects are expected for persons with a background in electronics.
Industrial machinery repairers	330,000	29	95,000	Employment expected to grow about as fast as average due to the need to maintain complex machinery used increasingly in manufacturing, coal mining, oil exploration, and other industries.
Millwrights	91,000	33	30,000	Employment expected to increase faster than average due to construction of new plants, improvements in existing plants, and installation and maintenance of increasingly complex machinery.
Musical instrument repairers	14,000	23	3,100	Employment expected to increase about as fast as average due to the increasing number of instruments in use.
Office machine repairers	56,000	72	40,000	Employment expected to grow much faster than average as the number of machines increases. Employment prospects will be good.
CONSTRUCTION OCCUPATIONS				
Bricklayers and stonemasons	124,000	33	41,000	Employment expected to grow faster than average as more homes, factories, offices, and other structures that use brick are built.
Carpenters	863,000	29	247,000	Employment expected to grow about as fast as average due to increasing construction of new structures and alteration and maintenance of old ones. Carpenters with all-round training will have the best prospects.
Cement masons and terrazzo workers	95,000	43	41,000	Employment expected to increase faster than average due to growing construction activity and greater use of concrete as a building material.
Drywall applicators and tapers	76,000	41	31,000	Employment expected to grow faster than average due to increasing commercial and residential construction.
Electricians	542,000	32	173,000	Employment expected to increase faster than average as more electricians are needed to install electrical fixtures and wiring in new and renovated buildings and to maintain electrical systems used by industry.
Floor covering installers	79,000	29	23,000	Employment expected to increase about as fast as average due to widespread use of resilient floor coverings and carpeting. Opportunities are likely to be best for persons able to install both carpeting and resilient flooring.
Glaziers	41,000	35	14,000	Employment expected to increase faster than average as demand increases for new residential and commercial buildings.
Insulation workers	47,000	44	20,000	Employment expected to grow faster than average as greater emphasis is placed upon energy efficiency of houses and other buildings.
Ironworkers	93,000	39	36,000	Employment expected to increase faster than average due to growing demand for nonresidential buildings, power transmission towers, and highway and bridge maintenance.
Painters	362,000	23	82,000	Employment expected to grow about as fast as average as more workers are needed to paint new and existing buildings and industrial structures.

Job Outlook

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982–95[1]	Numerical change in employment 1982–95[1]	Employment prospects
CONSTRUCTION OCCUPATIONS—continued				
Paperhangers	19,000	24	4,700	Employment expected to increase about as fast as average due to the continued popularity of wallpaper and other wall coverings.
Plasterers	20,000	7	1,500	Employment expected to grow more slowly than average due to continued preference for drywall instead of plaster. Employment opportunities will be better than they were in the 1960's and 1970's, however, as plaster regains some popularity and older structures with plaster walls are renovated.
Plumbers and pipefitters	388,000	34	131,000	Employment expected to grow faster than average as a result of increased construction activity and the need to repair and modernize existing plumbing and piping.
Roofers	102,000	27	27,000	Employment expected to grow about as fast as average as a result of new construction and the need to replace existing roofs.
Sheet-metal workers	87,000[2]	46	40,000	Employment expected to increase faster than average due to use of air-conditioning and heating ducts and other sheet-metal products in new construction and high demand for more efficient air-conditioning and heating systems in existing buildings.
Tilesetters	20,000	35	6,800	Employment expected to increase faster than average as tile is increasingly used in homes and commercial buildings.
PRODUCTION OCCUPATIONS				
Blue collar worker supervisors	1,200,000	27	320,000	Employment expected to increase about as fast as average. Nonmanufacturing industries—especially trade and services—will account for a large part of the increase.
Precision production occupations				
Boilermakers	40,000	8	3,000	Employment expected to grow more slowly than average due to the anticipated slow growth of industries that use boilers. Opportunities are expected to be best for experienced workers to maintain and repair existing equipment.
Bookbinders	30,000	20	6,100	Employment expected to grow about as fast as average in response to growth in the printing industry. Opportunities for machine bookbinders are expected to be better than those for hand bookbinders.
Butchers and meatcutters	191,000	−6	−12,000	Employment expected to decline because of centralized cutting and wrapping of meat for several stores at one location and cutting and boxing of meat in factories.
Compositors and typesetters	104,000	−7	−7,600	Employment expected to decline due to computerization of composition and typesetting. Job opportunities will be scarce.
Dental laboratory technicians	51,000	26	13,000	Employment expected to grow about as fast as average due to rising incomes, growing popularity of orthodontal work, and the increasing number of older persons who require dentures. Intensified competition among dentists could lead to more aggressive marketing of orthodontal and restorative dentistry, causing demand for dental laboratory services to rise even more. Excellent opportunities are expected for graduates of approved programs.
Dispensing opticians and ophthalmic laboratory technicians	39,000	24	9,400	Employment expected to increase about as fast as average as demand for corrective lenses rises. The employment of dispensing opticians is expected to grow more rapidly than that of ophthalmic laboratory technicians because of productivity improvements in optical laboratories.

CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982-95[1]	Numerical change in employment 1982-95[1]	Employment prospects
Furniture upholsterers	37,000	8	3,100	Employment expected to increase more slowly than average as people buy new furniture instead of reupholstering the old.
Hand molders	9,100	18	1,600	Employment expected to increase more slowly than average. Although strong demand is likely for metal castings, labor-saving innovations will limit employment growth.
Jewelers	30,000	13	4,000	Employment expected to grow more slowly than average. Best prospects are likely to be in jewelry stores. Attending a good technical school can improve job prospects.
Job and die setters	95,000	27	26,000	Employment expected to increase about as fast as average as demand for machined goods grows. Numerically controlled machine tools are expected to limit the need for additional workers.
Lithographers and photoengravers	67,000	29	20,000	Employment is expected to increase faster than average for lithographers and decline for photoengravers in response to the shift from letterpress to offset printing. Job opportunities will be best for graduates of postsecondary school programs in printing technology.
Machinists and layout markers	236,000	26	62,000	Employment expected to increase about as fast as average due to higher demand for machined metal parts. However, technological developments, such as computer controlled machine tools, are expected to keep employment from growing as fast as the demand for machined parts.
Patternmakers	13,000	17	2,300	Employment expected to grow more slowly than average. Improvements in metal casting technology will allow production to increase faster than employment.
Photographic process workers	67,000	17	11,000	Employment expected to grow more slowly than average due to the increased use of automated processing equipment.
Shoe repair occupations	16,000	15	2,400	Employment expected to grow more slowly than average. Job prospects should be good, nonetheless; because training is difficult to obtain, experienced or trained repairers are in demand.
Toolmakers and diemakers	154,000	21	33,000	Employment expected to grow about as fast as average due to higher demand for machined metal parts, although the use of computer controlled machine tools and improvements in tool design are expected to limit the need for new workers. Due to the long training period for these workers, temporary shortages may occur in areas with many manufacturing firms.
Plant and system operators				
Stationary engineers	58,000	4	2,200	Little change in employment expected despite expansion in industry and growth in the number of buildings, due to greater automation of equipment.
Water and sewage treatment plant operators	72,000	10	7,400	Employment expected to grow more slowly than average due to a slowdown in construction and modernization of treatment plants. Job prospects are likely to be best for those with formal training.
Machine operators, tenders, and setup workers				
Machine tool operators	914,000	22	200,000	Employment expected to increase about as fast as average as the metalworking industries recover from the 1981-82 recession. Over the long run, the use of faster and more versatile automatic machine tools will tend to limit the demand for unskilled operators.
Printing press operators	174,000	18	32,000	Employment expected to increase more slowly than average as faster and more efficient presses accommodate growing output. Competition for jobs is expected.

Job Outlook

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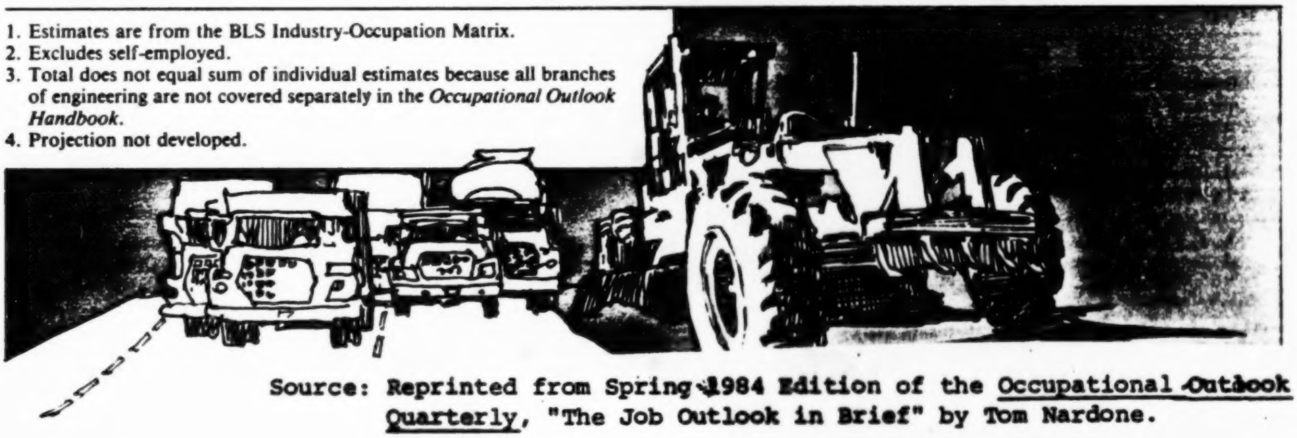
CLUSTER Subgroup Occupation	Estimated employment 1982[1]	Percent change in employment 1982-95[1]	Numerical change in employment 1982-95[1]	Employment prospects
PRODUCTION OCCUPATIONS—continued				
Fabricators, assemblers, and handworking occupations				
Assemblers	1,313,000	25	332,000	Employment expected to increase about as fast as average. Since most jobs are in durable goods industries, economic conditions and national defense spending will continue to affect job prospects.
Automotive painters	36,000	46	17,000	Employment expected to increase faster than average due to the growing number of vehicles and traffic accidents.
Welders and flamecutters	490,000	21	105,000	Employment expected to grow about as fast as average. Automated welding systems are likely to slow growth in some industries, but highly skilled welders will continue to be in demand.
TRANSPORTATION AND MATERIAL MOVING OCCUPATIONS				
Airplane pilots	80,000	29	23,000	Employment expected to grow about as fast as average due to increased air travel. Keen competition, especially for jobs with the major airlines. Opportunitites are expected to be best for college graduates with flying experience.
Busdrivers	473,000	17	78,000	Employment expected to increase more slowly than average, but job openings will be plentiful for school busdrivers.
Construction machinery operators (operating engineers)	202,000[2]	44	89,000	Employment expected to grow faster than average due to increasing construction activity. Job opportunities should be plentiful, especially in highway and bridge maintenance and the construction of mass transit systems.
Industrial truck operators	385,000	18	70,000	Employment expected to increase more slowly than average due to increased use of computerized material handling systems.
Truckdrivers	2,402,000	24	578,000	Employment expected to grow about as fast as the average due to growth in the amount of freight being shipped. Keen competition is likely for jobs in this high-paying occupation.
HANDLERS, EQUIPMENT CLEANERS, HELPERS, AND LABORERS				
Construction laborers and helpers	576,000	29	165,000	Employment expected to grow about as fast as average. Job openings should be plentiful because turnover is high.

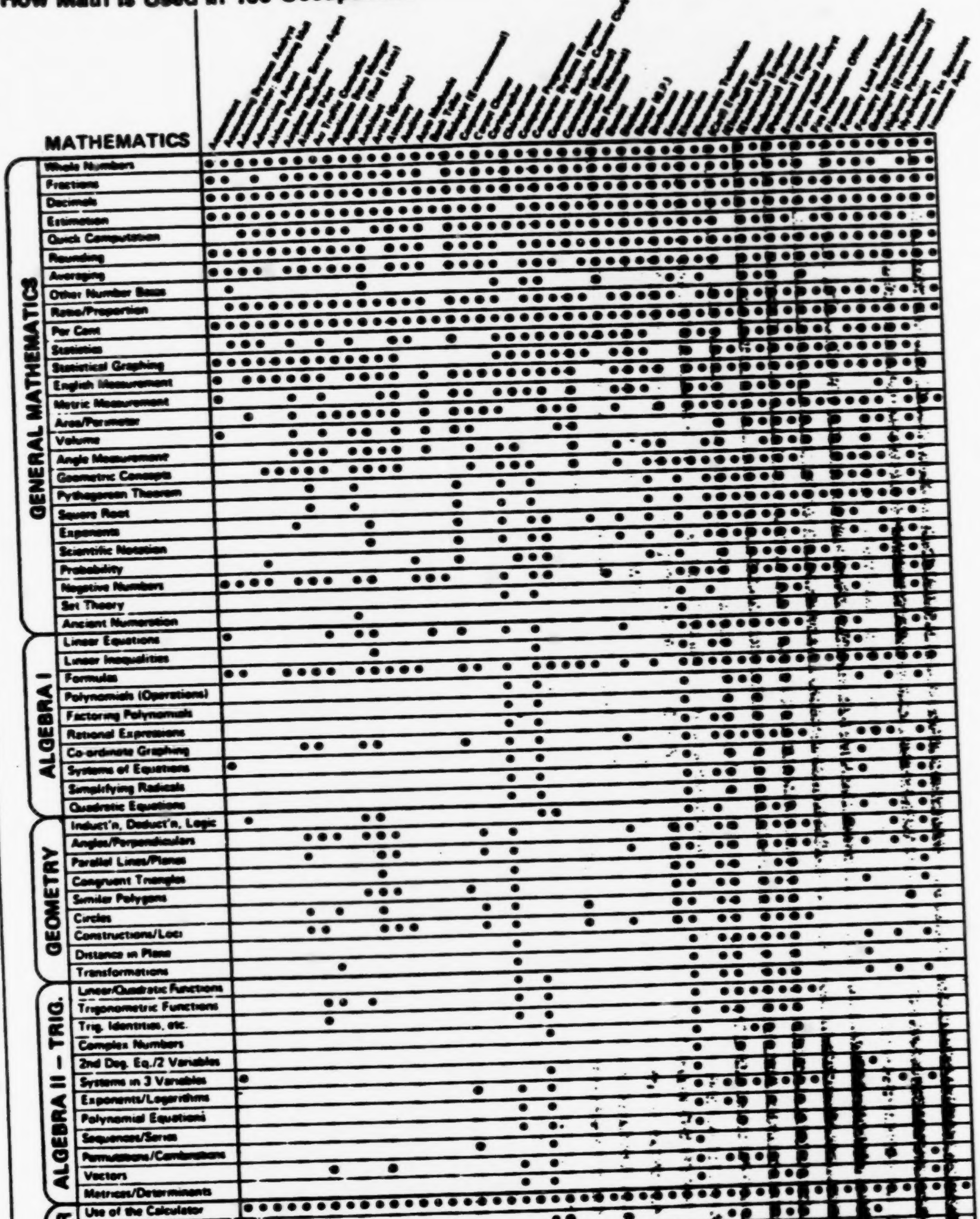
1. Estimates are from the BLS Industry-Occupation Matrix.
2. Excludes self-employed.
3. Total does not equal sum of individual estimates because all branches of engineering are not covered separately in the *Occupational Outlook Handbook*.
4. Projection not developed.



Source: Reprinted from Spring 1984 Edition of the Occupational Outlook Quarterly, "The Job Outlook in Brief" by Tom Nardone.

APPENDIX B

How Math Is Used in 100 Occupations*


MATHEMATICS
GENERAL MATHEMATICS
Whole Numbers
Fractions
Decimals
Estimation
Quick Computation
Rounding
Averaging
Other Number Bases
Ratio/Proportion
Per Cent
Statistics
Statistical Graphing
English Measurement
Metric Measurement
Area/Perimeter
Volume
Angle Measurement
Geometric Concepts
Pythagorean Theorem
Square Root
Exponents
Scientific Notation
Probability
Negative Numbers
Set Theory
Ancient Numeration
ALGEBRA I
Linear Equations
Linear Inequalities
Formulas
Polynomials (Operations)
Factoring Polynomials
Rational Expressions
Co-ordinate Graphing
Systems of Equations
Simplifying Radicals
Quadratic Equations
GEOMETRY
Induct'n, Deduct'n, Logic
Angles/Perpendiculars
Parallel Lines/Planes
Congruent Triangles
Similar Polygons
Circles
Constructions/Loci
Distance in Plane
Transformations
ALGEBRA II — TRIG.
Linear/Quadratic Functions
Trigonometric Functions
Trig. Identities, etc.
Complex Numbers
2nd Deg. Eq./2 Variables
Systems in 3 Variables
Exponents/Logarithms
Polynomial Equations
Sequences/Series
Permutations/Combinations
Vectors
Matrices/Determinants
OTHER
Use of the Calculator
Computer Operations
Computer Programming
Higher Mathematics

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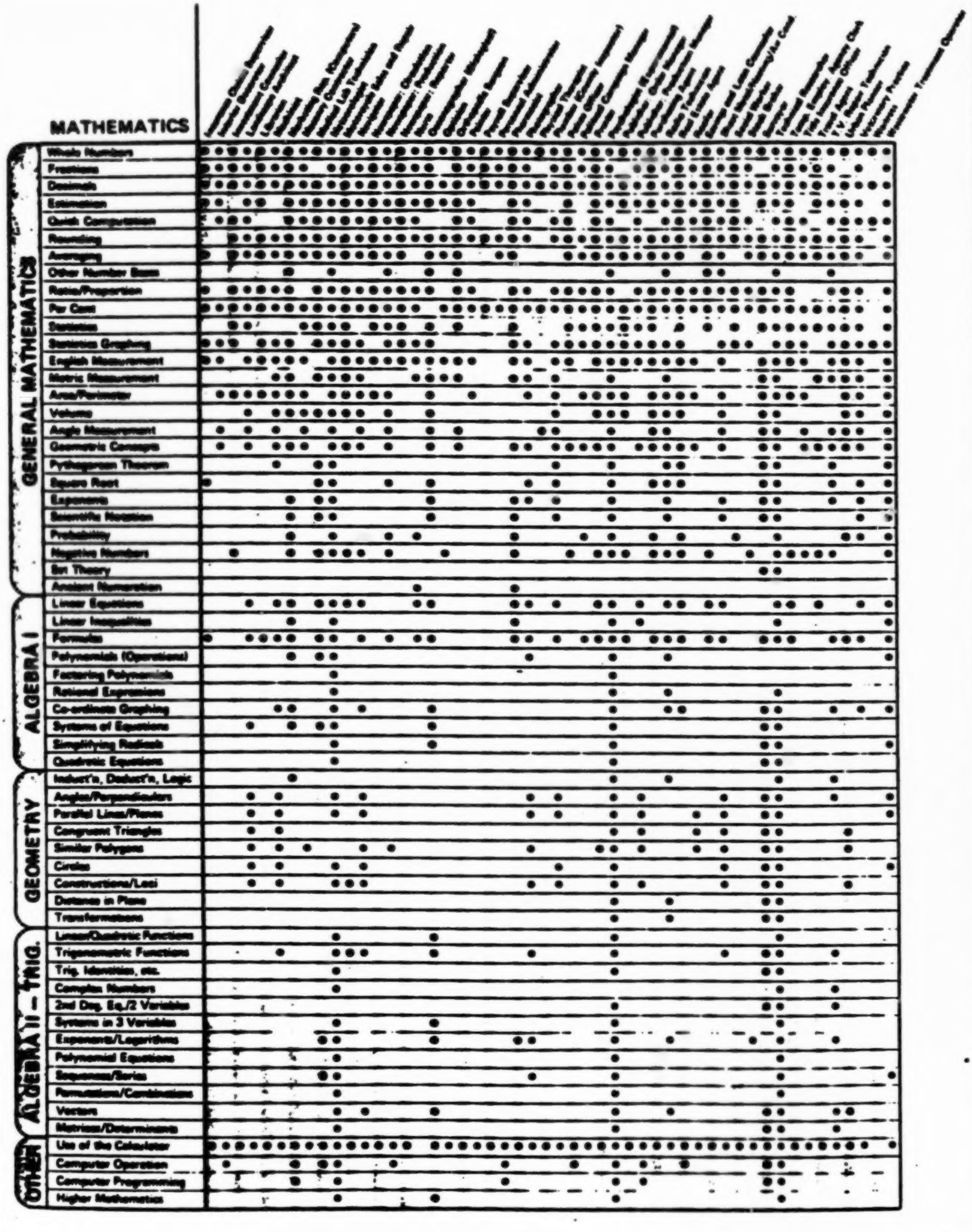
Source: Reprinted from "Math and Your Careers" by Gail M. Martin in the *Occupational Outlook Quarterly* (Summer 1983).



MATHEMATICS

GENERAL MATHEMATICS
- Whole Numbers
- Fractions
- Decimals
- Estimation
- Quick Computation
- Rounding
- Averaging
- Other Number Bases
- Ratio/Proportion
- Per Cent
- Statistics
- Statistics Graphing
- English Measurement
- Metric Measurement
- Area/Perimeter
- Volume
- Angle Measurement
- Geometric Concepts
- Pythagorean Theorem
- Square Root
- Exponents
- Scientific Notation
- Probability
- Negative Numbers
- Set Theory
- Ancient Numeration

ALGEBRA I
- Linear Equations
- Linear Inequalities
- Formulas
- Polynomials (Operations)
- Factoring Polynomials
- Rational Expressions
- Co-ordinate Graphing
- Systems of Equations
- Simplifying Radicals
- Quadratic Equations

GEOMETRY
- Induct'n, Deduct'n, Logic
- Angles/Perpendiculars
- Parallel Lines/Planes
- Congruent Triangles
- Similar Polygons
- Circles
- Constructions/Loci
- Distance in Plane
- Transformations

ALGEBRA II – TRIG.
- Linear/Quadratic Functions
- Trigonometric Functions
- Trig. Identities, etc.
- Complex Numbers
- 2nd Deg. Eq./2 Variables
- Systems in 3 Variables
- Exponents/Logarithms
- Polynomial Equations
- Sequences/Series
- Permutations/Combinations
- Vectors
- Matrices/Determinants

OTHER
- Use of the Calculator
- Computer Operation
- Computer Programming
- Higher Mathematics

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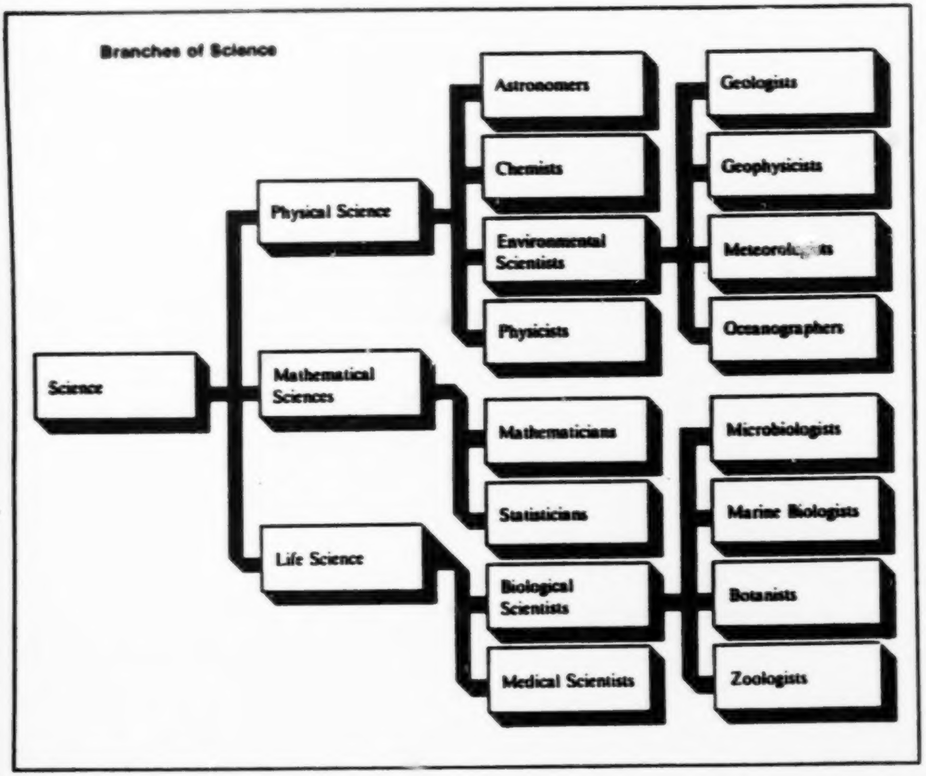
APPENDIX C


Branches of Science
Science
Physical Science
Mathematical Sciences
Life Science
Astronomers
Chemists
Environmental Scientists
Physicists
Mathematicians
Statisticians
Biological Scientists
Medical Scientists
Geologists
Geophysicists
Meteorologists
Oceanographers
Microbiologists
Marine Biologists
Botanists
Zoologists

Some Occupations Related to the Physical Sciences

High school graduation usually necessary or recommended

- Air conditioning technician
- Computer service technician
- Cook and chef
- Electrician
- Elevator constructor
- Electroplater
- Electrotyper and stereotyper
- Instrument repairer
- Pest controller
- Photoengraver
- Printing press operator and assistant

Two years of college or specialized school usually necessary or recommended

- Engineering technician (various specialties)
- Nuclear technician
- Science technician (various specialties)

Four or more years of college usually necessary or recommended

- Aerospace engineer
- Acoustical engineer
- Anesthesiologist
- Anthropologist
- Archaeologist
- Astronomer
- Astrophysicists
- Biochemist

- Biomedical engineer
- Cartographer
- Ceramic engineer
- Chemical engineer
- Chemist
- Civil engineer
- Clinical chemist
- Computer engineer

- Consumer protection specialist
- Dentist
- Electrical engineer
- Environmental scientist
- Food and drug analyst
- Geographer
- Geological engineer
- Geologist

- Geophysicist
- Industrial engineer
- Illuminating engineer
- Mechanical engineer
- Metallurgical engineer
- Meteorologist
- Mineralogist
- Mining engineer
- Nuclear engineer
- Oceanographer
- Patent examiner
- Patent searcher
- Petroleum engineer
- Pharmacologist
- Physicist

- Quality control engineer
- Radar technician
- Safety engineer
- Seismologist
- Systems analyst
- Toxicologist
- Traffic engineer
- Wood technologist

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Reprinted from "Science and Your Career" by Gail M. Martin in the Occupational Outlook Quarterly (Summer 1983).

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